THE ENGINEER

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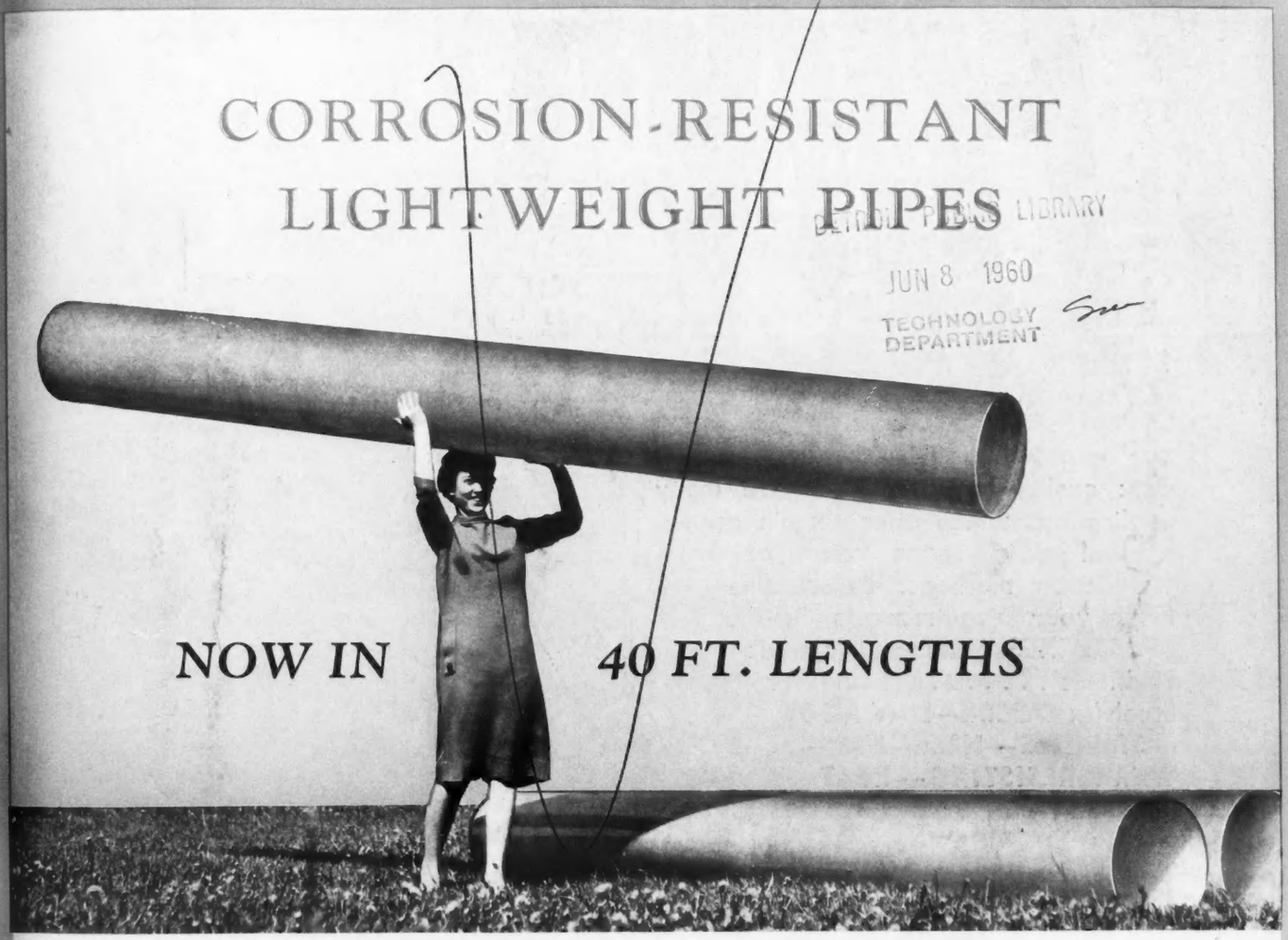

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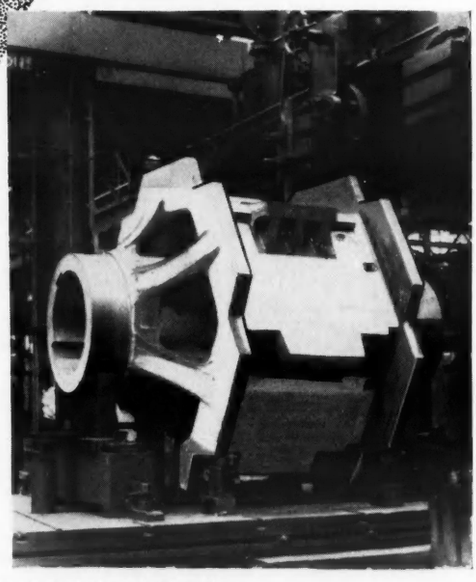

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Established 1856

No. 5443 MAY 20, 1960 VOL. 209

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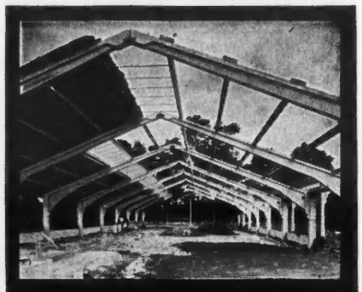

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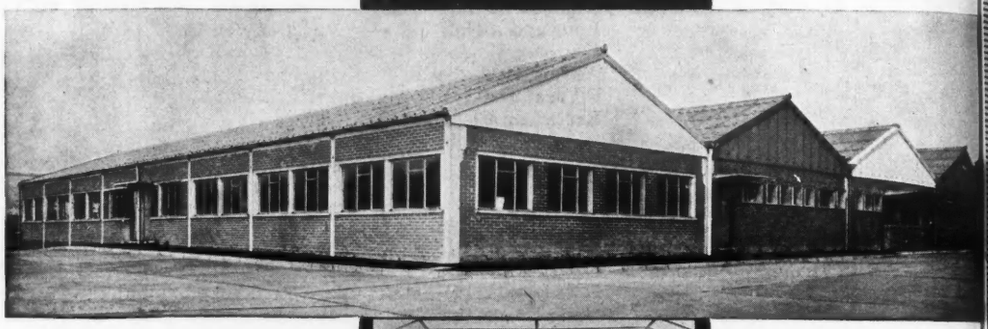

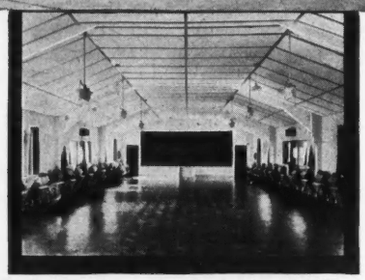

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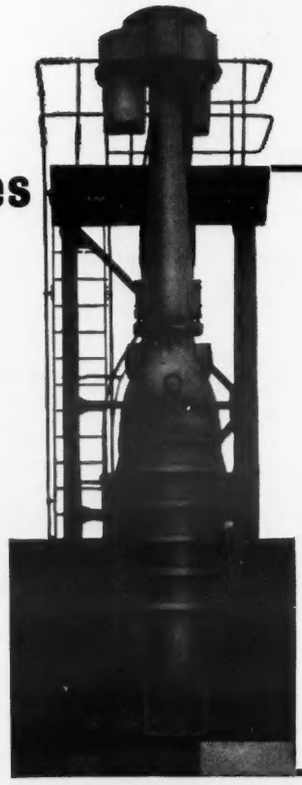

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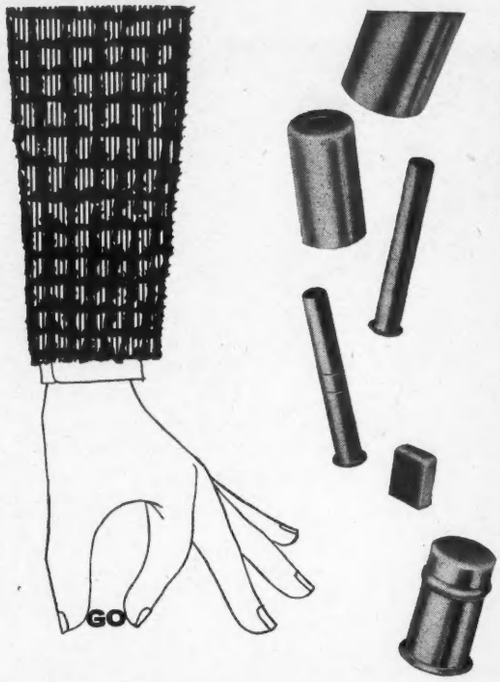

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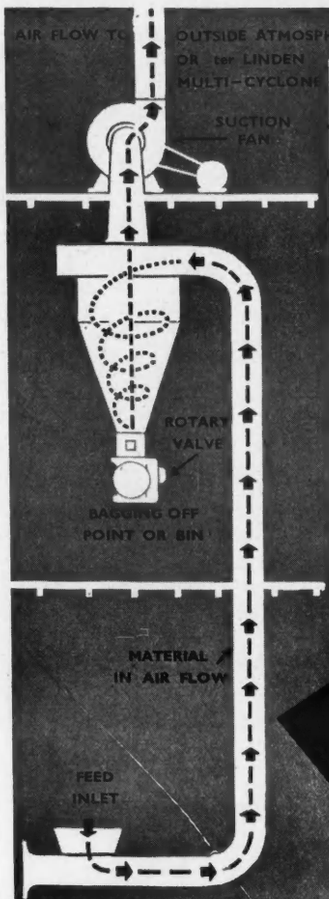

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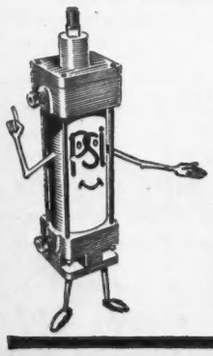

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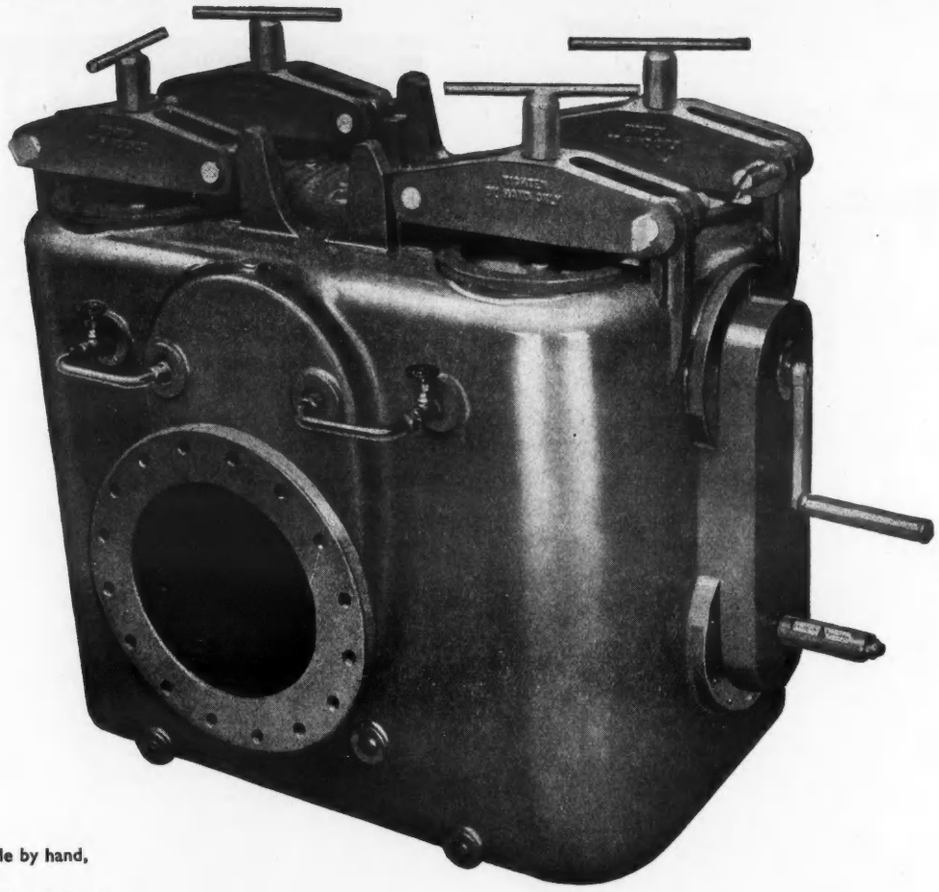

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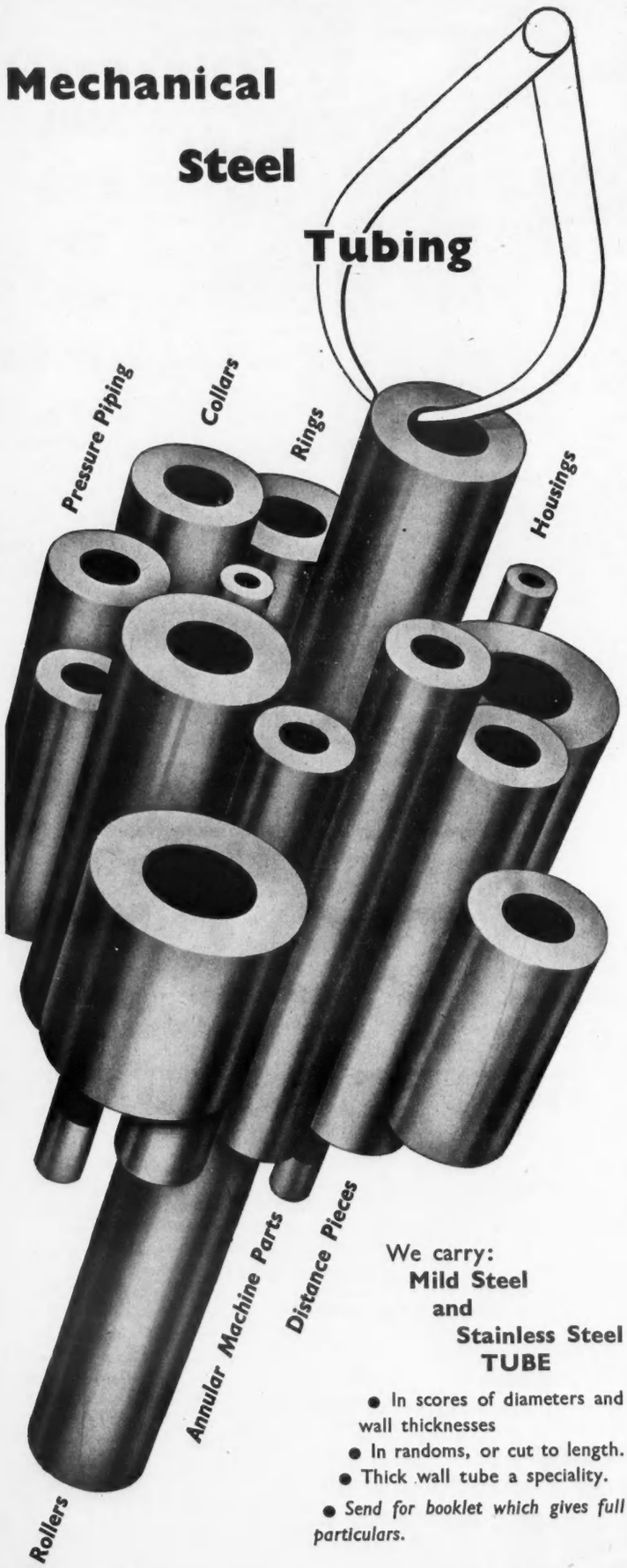

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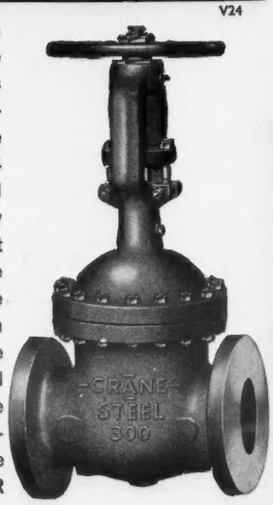

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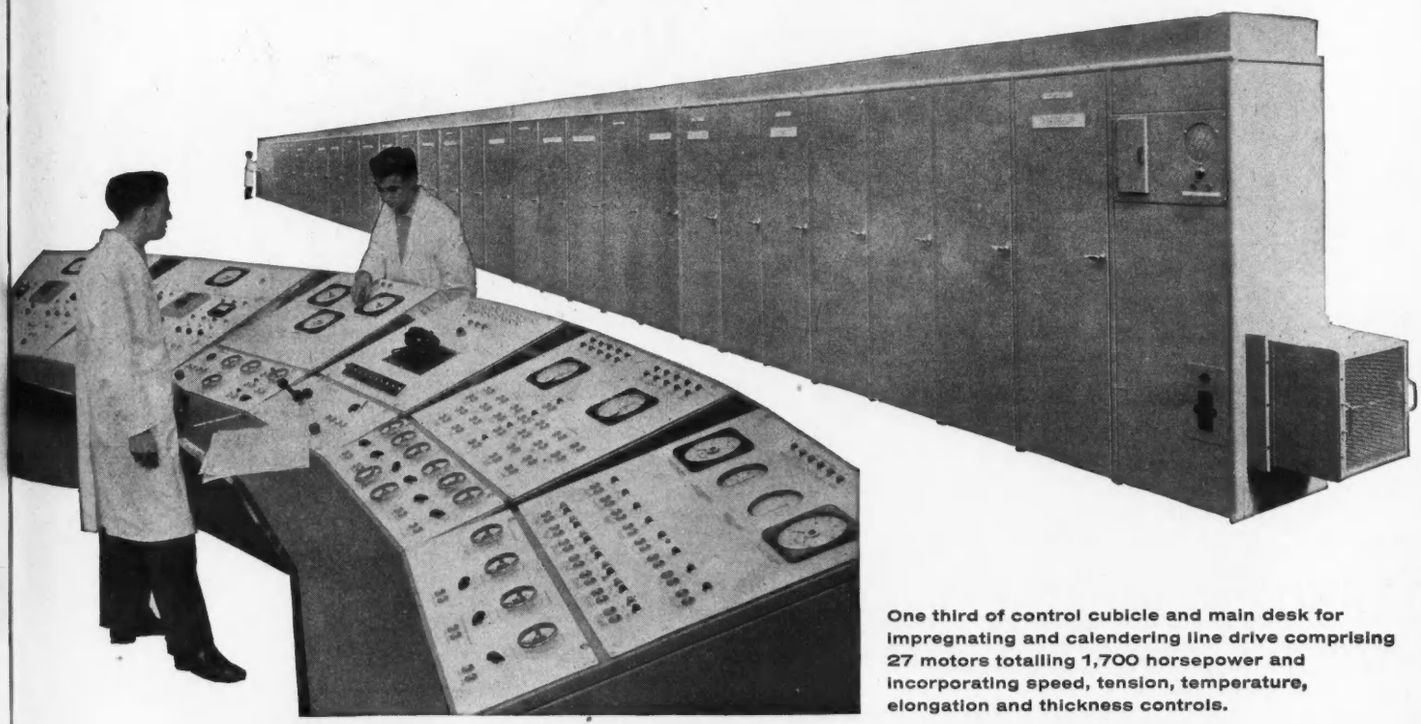

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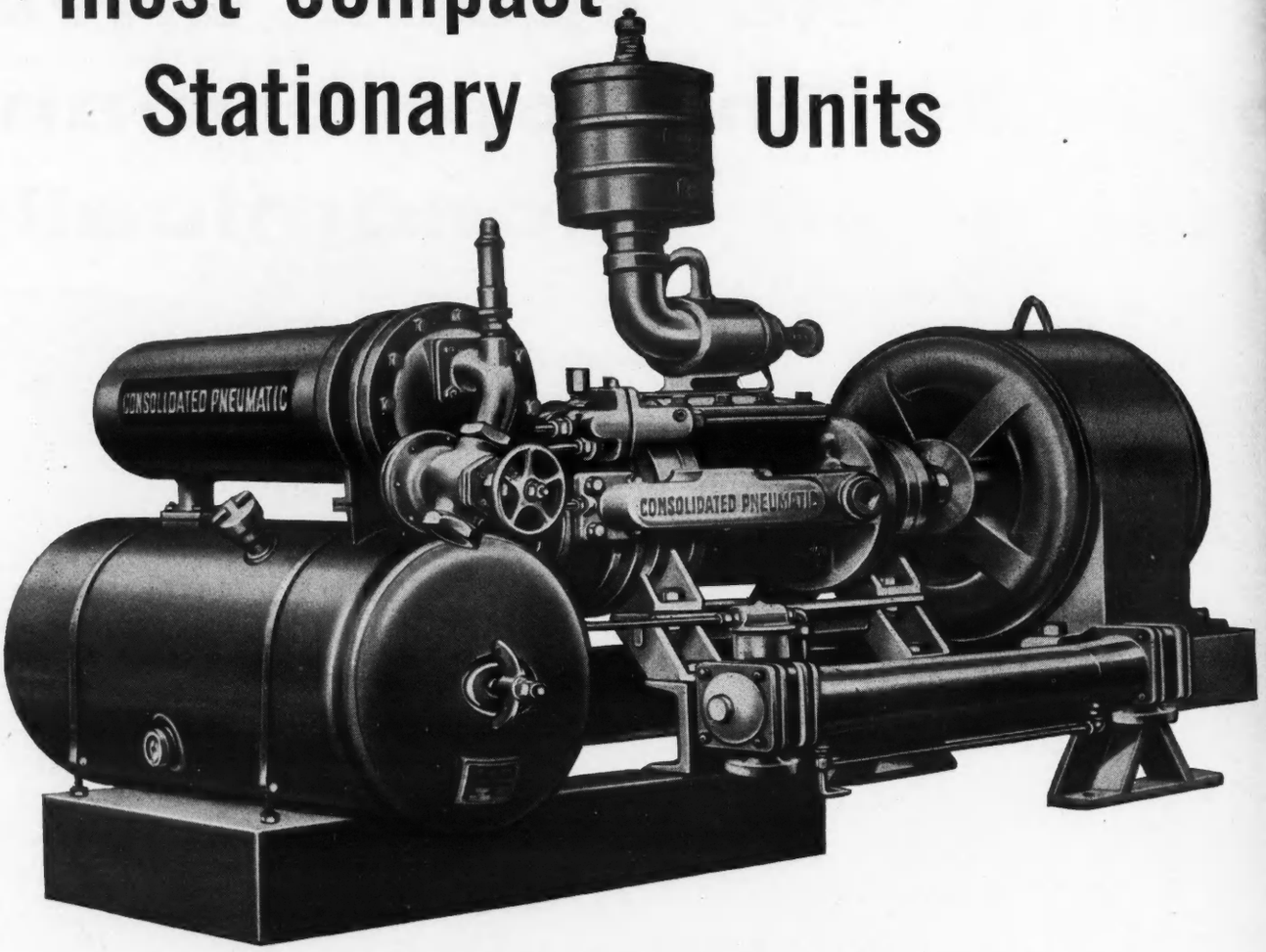

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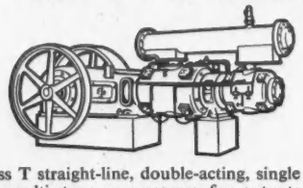

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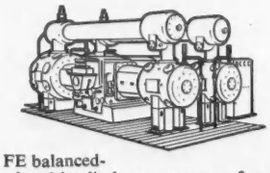

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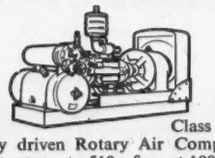

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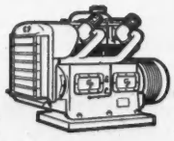

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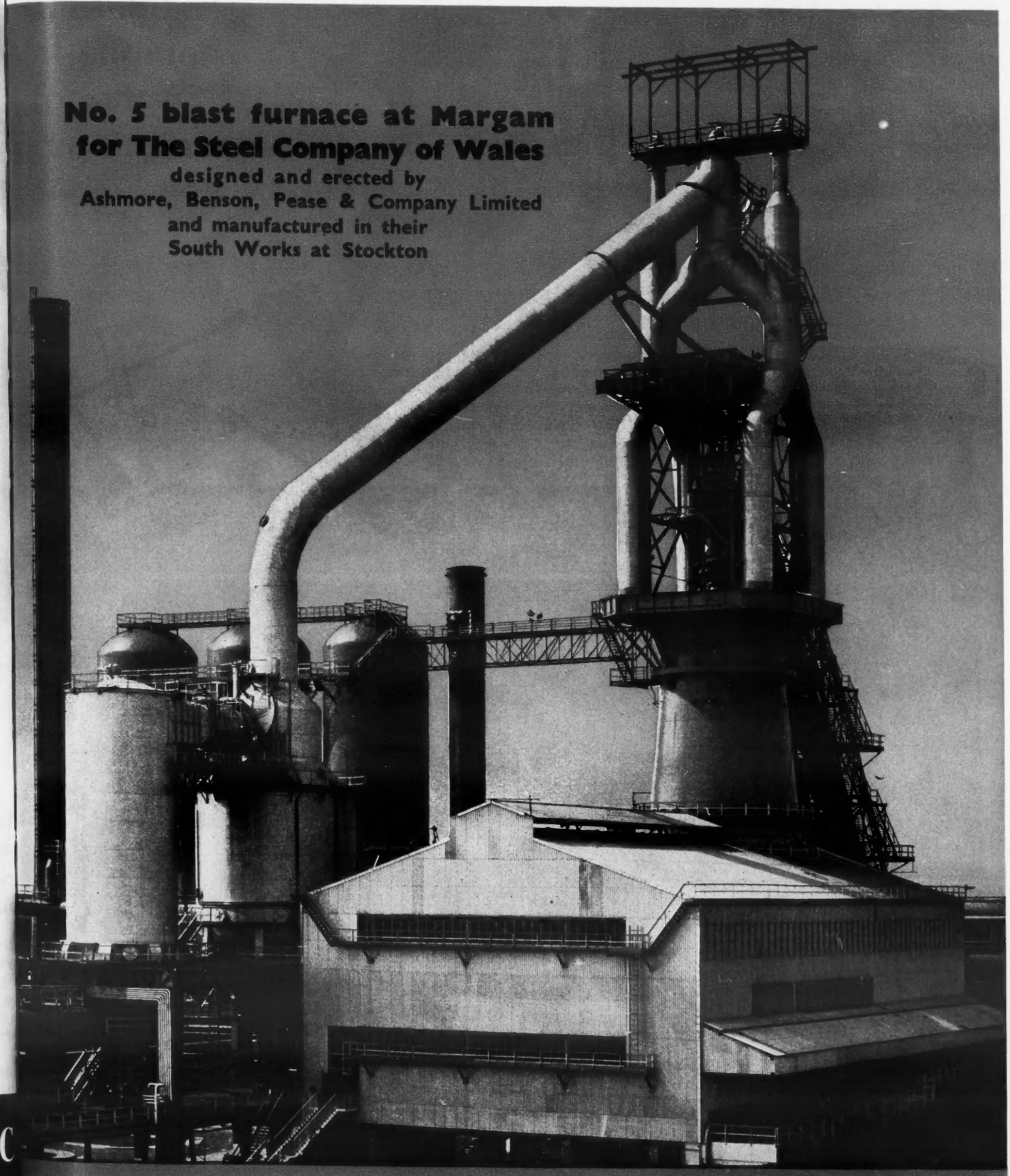
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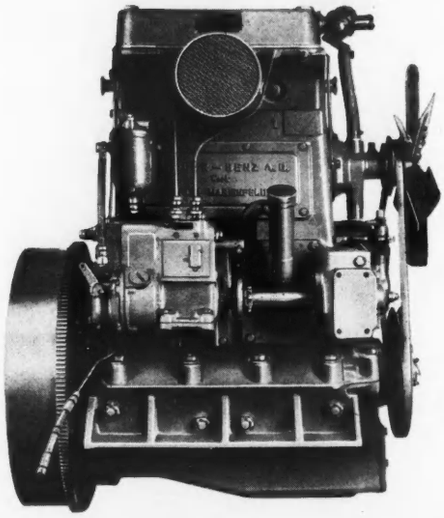

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Types and Performance Data Type	Cooling	No. of cylinders Arrangement	Output PS (DIN)	Speedrange R.P.M.	Cyl. Bore ins.	Stroke ins.	Piston displacement cu. ins.	Weight approx. lbs.
M 202 B	W	2/S	35 – 55	750 – 1200	5 1/2	8 1/4	394.8	1665
M 203 B	W	3/S	54 – 90	750 – 1200	5 1/2	8 1/4	591.9	2150
M 204 B	W	4/S	72 – 120	750 – 1200	5 1/2	8 1/4	789.0	2715
OM 636	W	4/S	17 – 35	1500 – 3000	2 15/16	3 15/16	107.8	495
OM 312	W	6/S	47 – 77	1500 – 2400	3 9/16	4 3/4	279.5	784
OM 321	W	6/S	55 – 94	1500 – 2600	3 3/4	4 3/4	311.2	784
OM 315	W	6/S	80 – 124	1200 – 1800	4 7/16	5 1/2	505.0	1700
OM 326	W	6/S	97 – 155	1200 – 1800	5 3/64	5 1/2	660.0	1720
MB 851	W	1/S	9 – 20	1000 – 2000	4 1/2	5 1/2	88.8	662
MB 861	L	1/S	9 – 20	1000 – 2000	4 1/2	5 1/2	88.8	662
MB 852	W	2/S	18 – 40	1000 – 2000	4 1/2	5 1/2	176.9	915
MB 862	L	2/S	18 – 40	1000 – 2000	4 1/2	5 1/2	176.9	915
MB 853	W	3/S	27 – 60	1000 – 2000	4 1/2	5 1/2	266	1122
MB 863	L	3/S	27 – 60	1000 – 2000	4 1/2	5 1/2	266	1122
MB 854	W	4/V	36 – 80	1000 – 2000	4 1/2	5 1/2	354.4	1245
MB 864	L	4/V	36 – 80	1000 – 2000	4 1/2	5 1/2	354.4	1245
MB 846 A	W	6/S	114 – 250	750 – 1500	5 7/8	7 1/2	1230.2	3860
MB 846 B	W	6/Li	114 – 250	750 – 1500	5 7/8	7 1/2	1230.2	3970
MB 846 Ab ▽	W	6/S	148 – 320	750 – 1500	5 7/8	7 1/2	1230.2	4080
MB 846 Ad ▼	W	6/S	148 – 320	750 – 1500	5 7/8	7 1/2	1230.2	4200
MB 846 Bb ▽	W	6/Li	148 – 320	750 – 1500	5 7/8	7 1/2	1230.2	4200
MB 836 B	W	6/S	240 – 375	1000 – 1500	6 7/8	8 1/16	1806.3	4380
MB 836 Bb ▽	W	6/S	320 – 525	1000 – 1500	6 7/8	8 1/16	1806.3	4830
MB 836 Db ▼	W	6/S	370 – 650	1000 – 1500	6 7/8	8 1/16	1806.3	5050
MB 820 B	W	12/V	460 – 750	1000 – 1500	6 7/8	8 1/16	612.6	6180
MB 820 Bb ▽	W	12/V	640 – 1100	1000 – 1500	6 7/8	8 1/16	3612.6	6900
MB 820 Db ▼	W	12/V	770 – 1350	1000 – 1500	6 7/8	8 1/16	3612.6	7240
MB 837 A	W	8/V	165 – 440	1000 – 2000	6 1/2	6 7/8	1825	2940
MB 837 Aa ▽ ▽	W	8/V	215 – 550	1000 – 2000	6 1/2	6 7/8	1825	3020
MB 835 Ab ▽	W	12/V	840 – 1450	1000 – 1500	7 1/2	9 1/2	4773	8157
MB 835 Bb ▼	W	12/V	1015 – 1780	1000 – 1500	7 1/2	9 1/2	4773	8597
MB 839 Ab ▽	W	16/V	1120 – 2000	1000 – 1500	7 1/2	9 1/16	6380	11020
MB 839 Bb ▼	W	16/V	1350 – 2400	1000 – 1500	7 1/2	9 1/16	6380	11450
MB 518 B ▼ ▼	W	20/V	3000	1720	7 5/16	9 13/16	8201.5	10550

Note:

W = water cooling · L = air cooling
Li = horizontal · S = vertical
V = vee type · ▽ = with exhaust-turbo-supercharging · ▼ = with exhaust-turbo-supercharging and boost intercooling · ▽ ▽ = with mechanical supercharging
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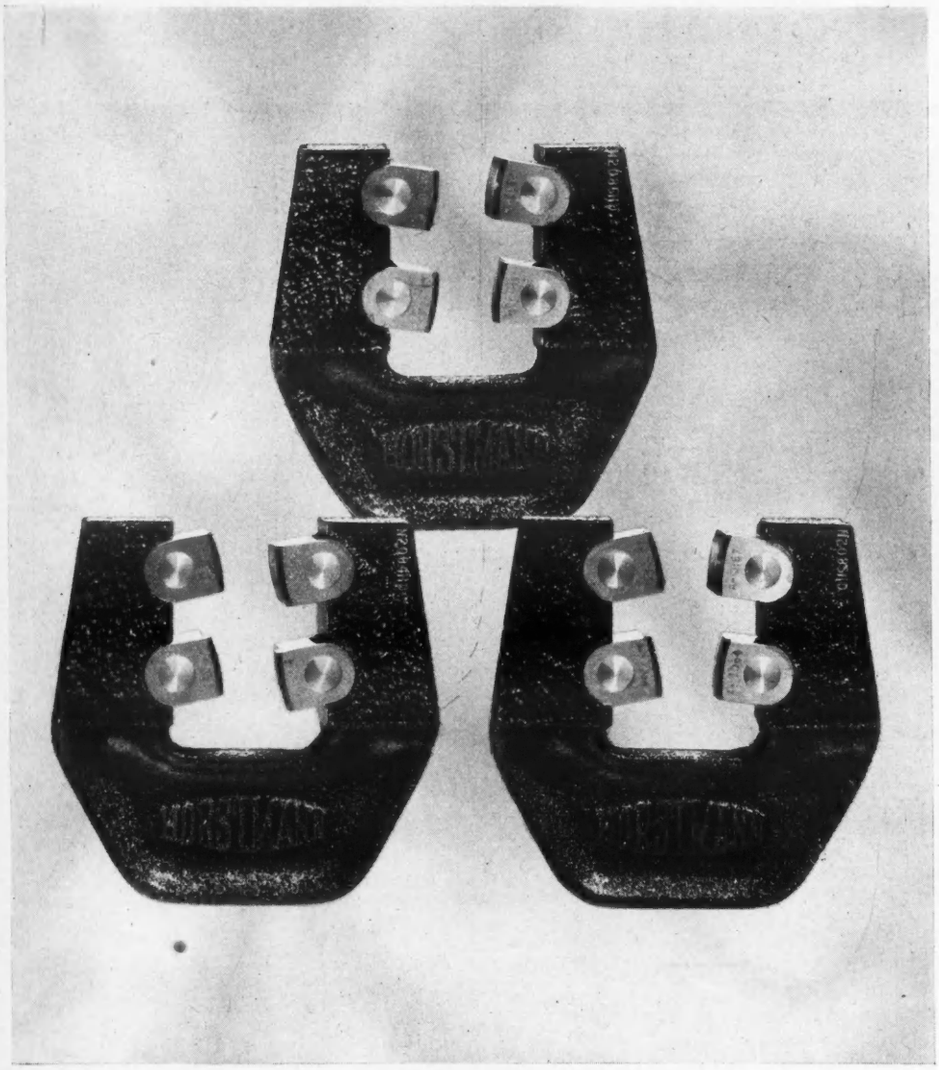

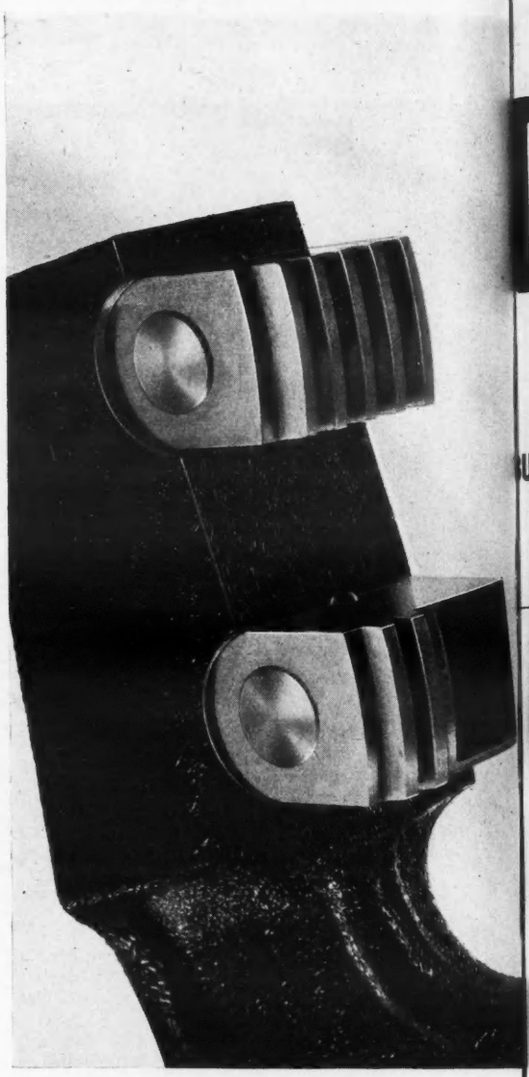

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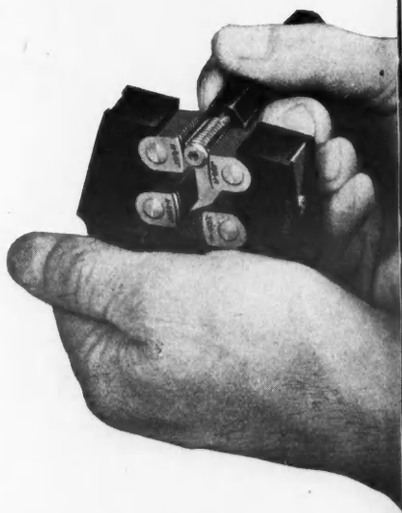

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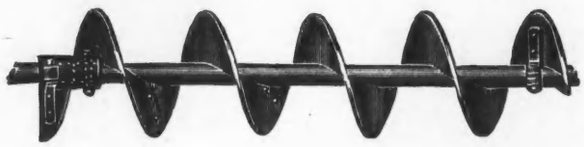

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29	30	50
210	10	140
211	50	20
212	10	80
213	30	20
214	50	10
215	10	40
216	20	20
217	20	10
218	10	20
219	10	10
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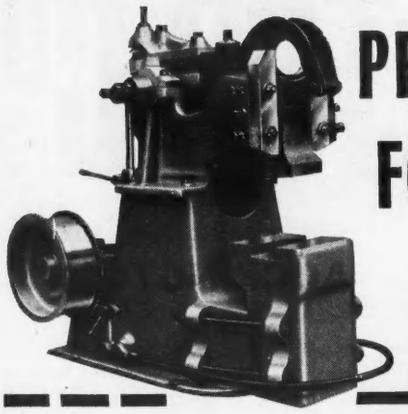

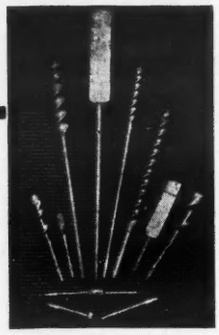

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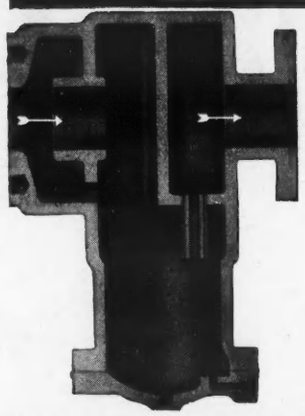

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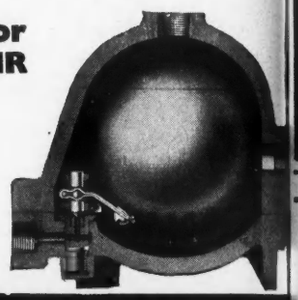

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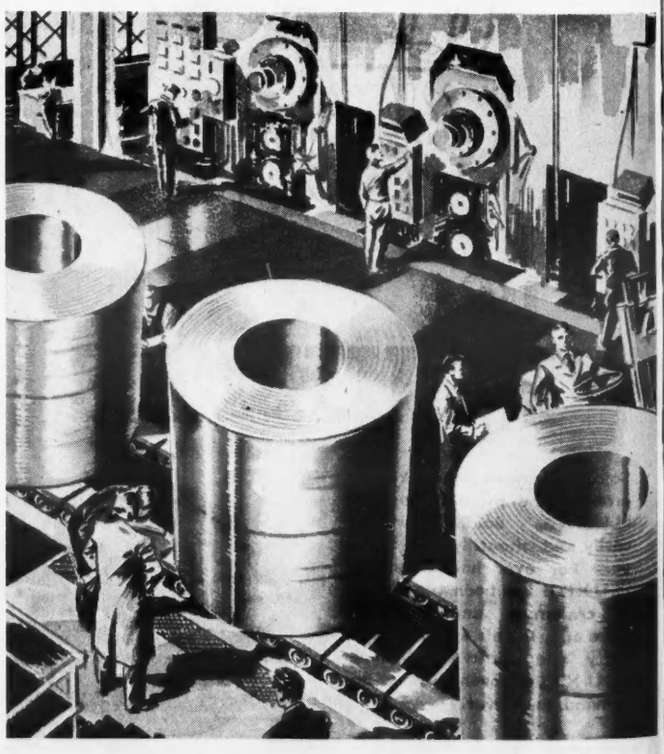

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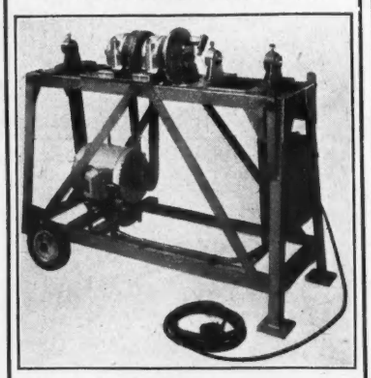

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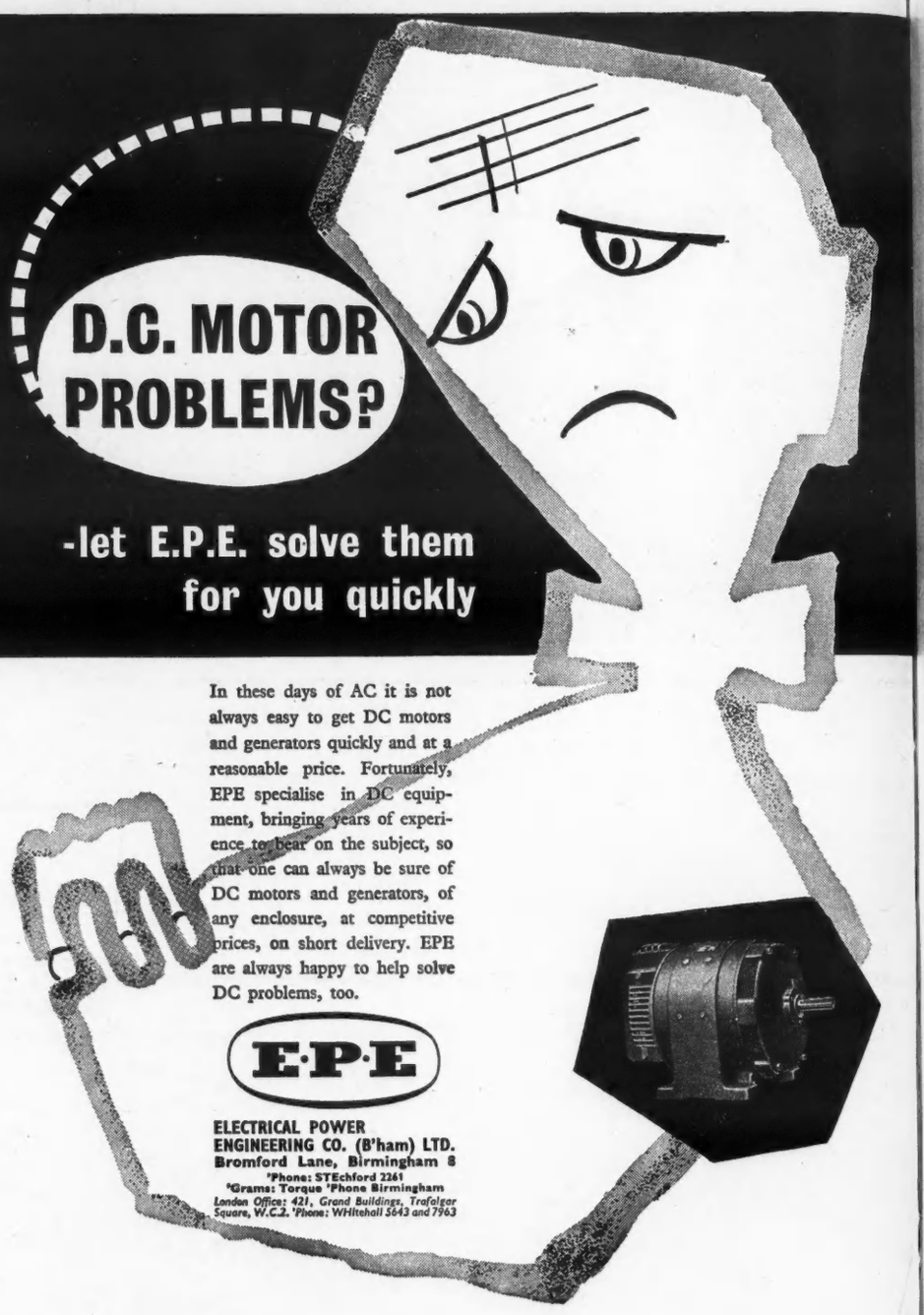

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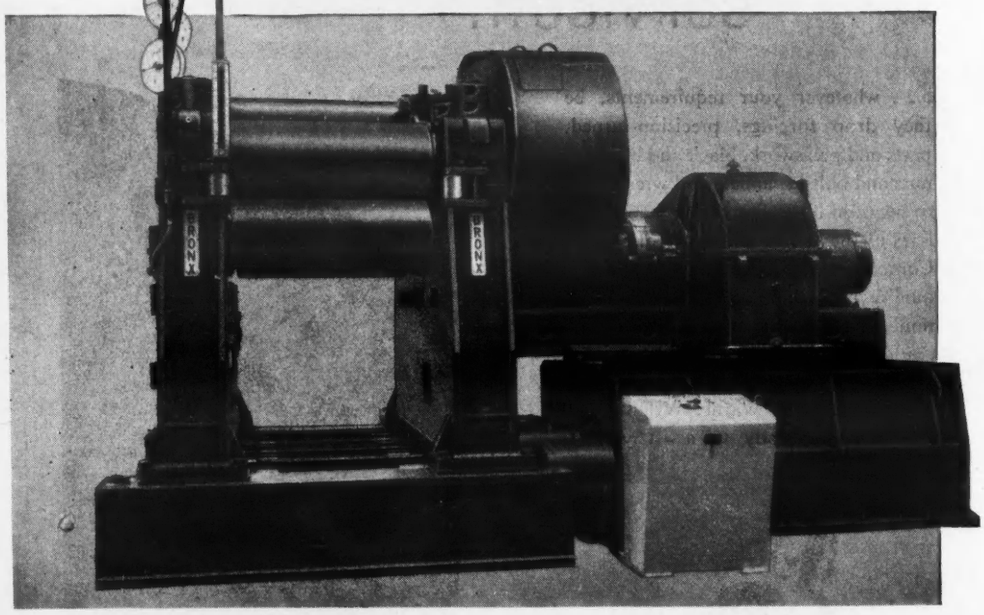

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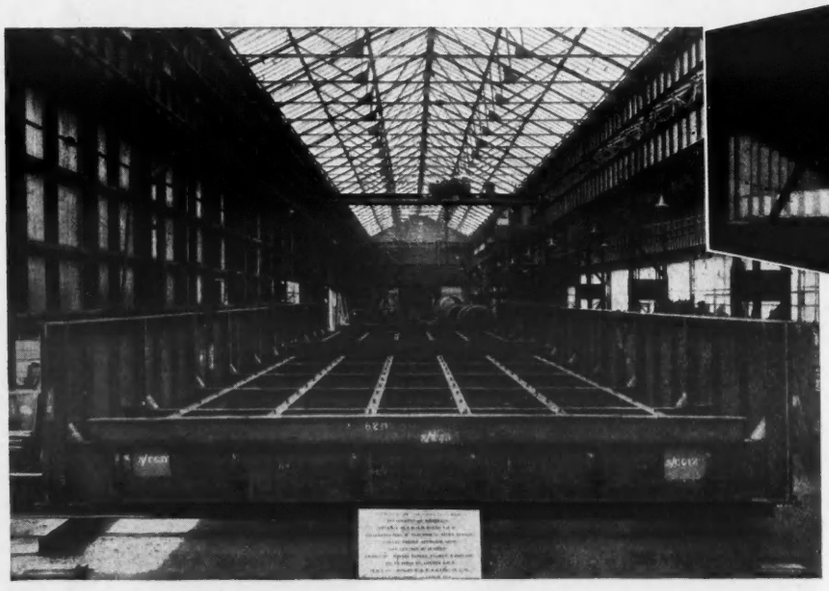

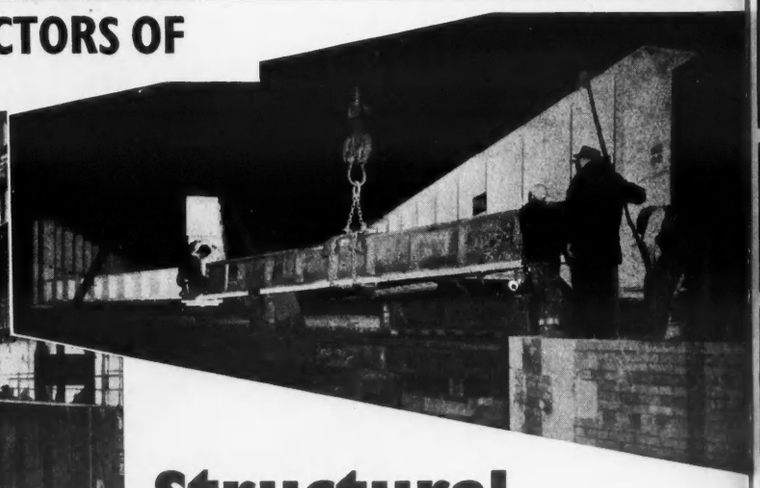

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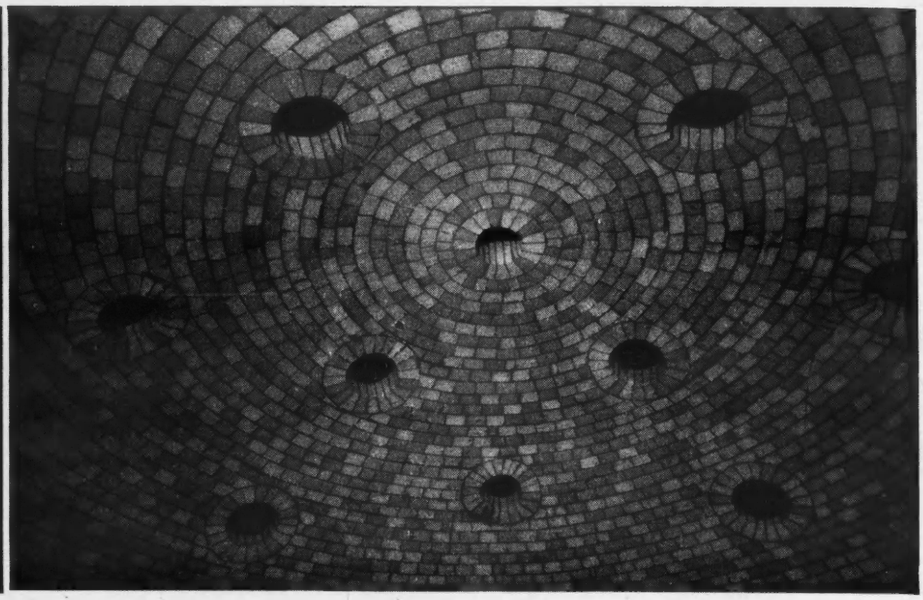

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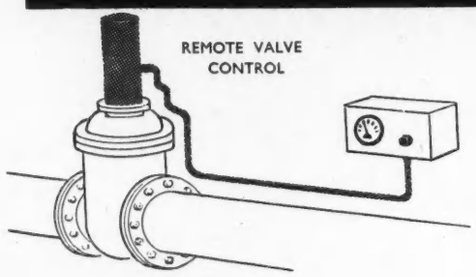

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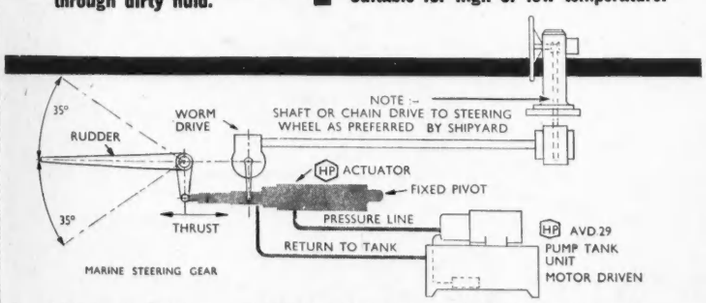

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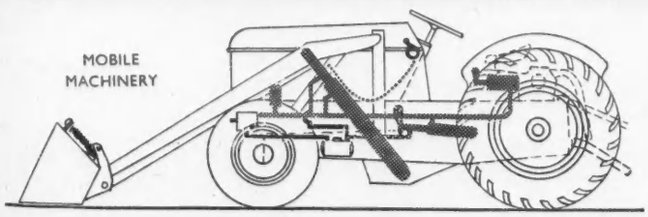

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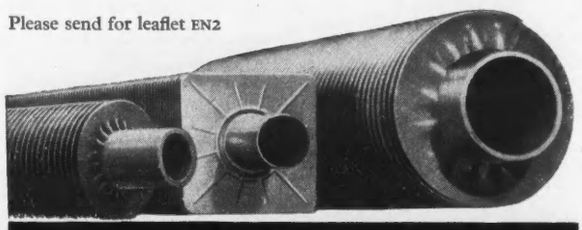

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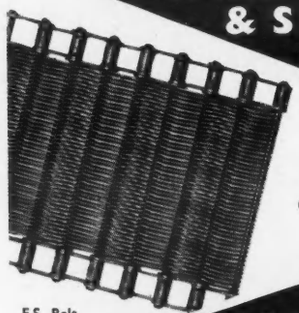

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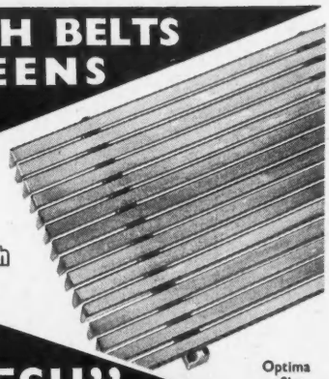

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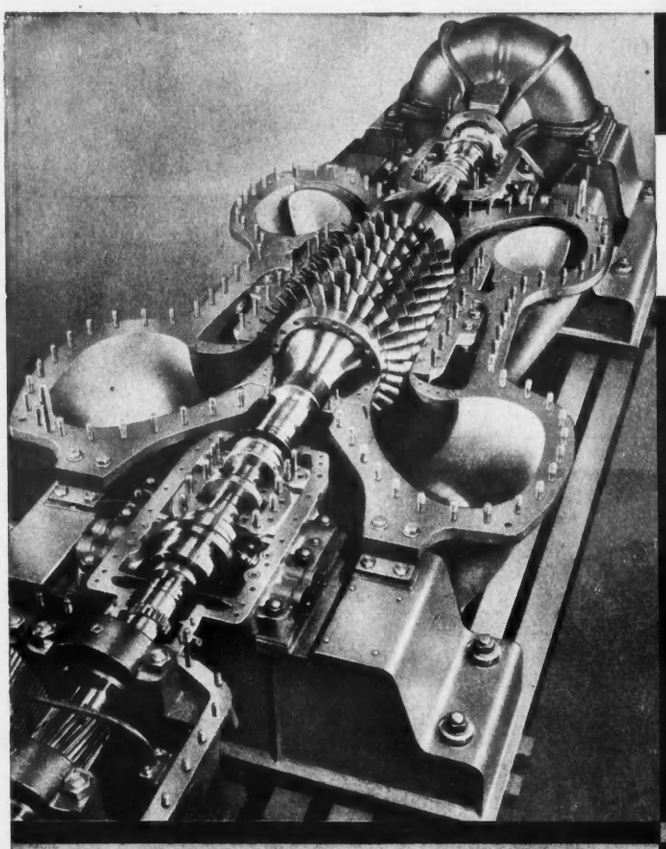

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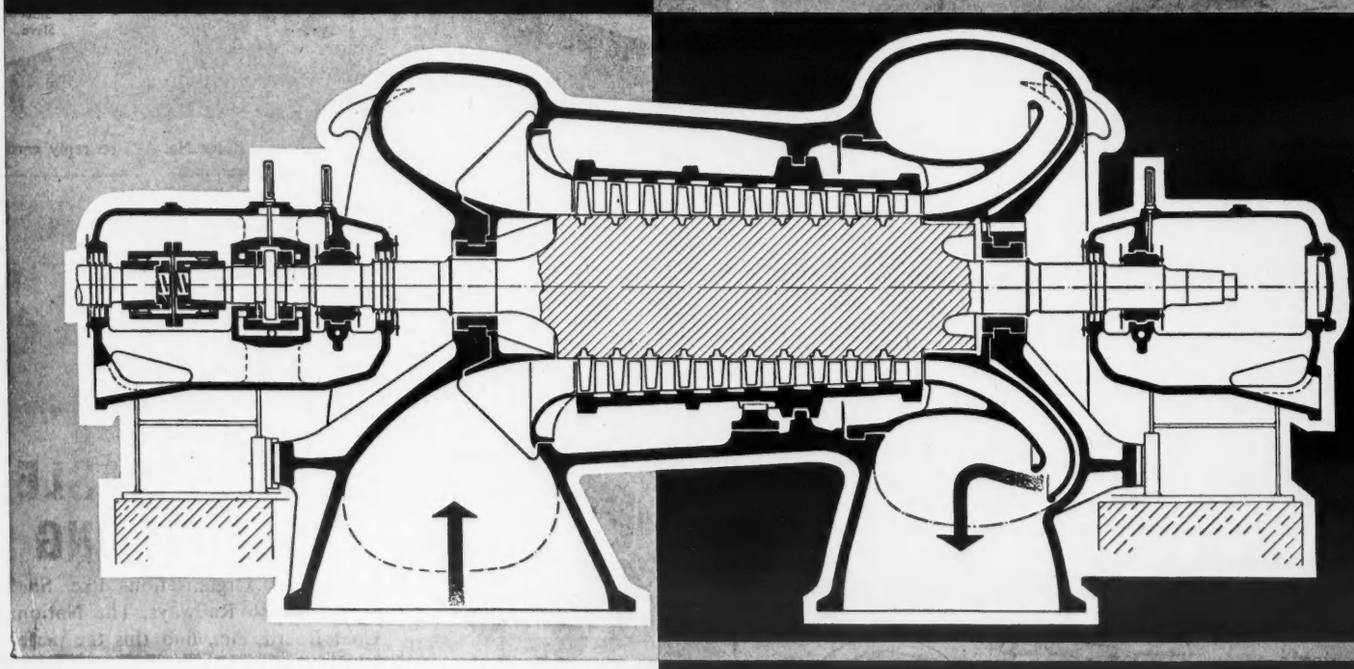

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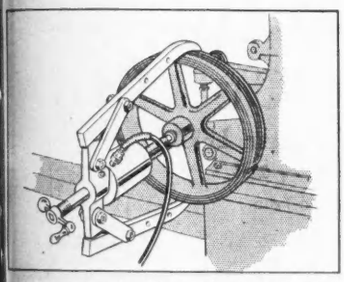
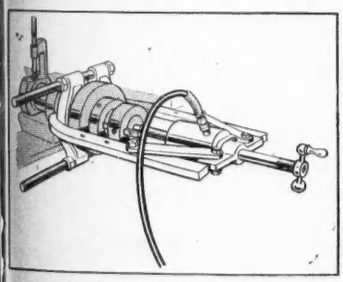
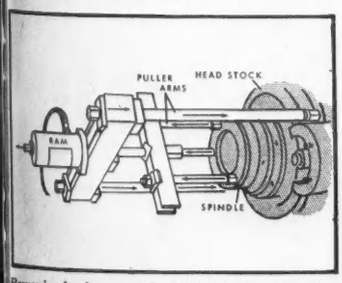


Removing belt drive wheel with HOLL-O-RAM Double or Triple-Grip Pullers. Note shaft-protection over centre hole and adjusting screw which contacts lead before power is applied.



Pulling Pulley Wheel and key from machine tool crankshaft using HOLL-O-RAM with Double-Grip Puller. Note Bearing Pulling attachment, used where puller jaws cannot be inserted.



Removing back gear and spindle prior to overhauling lap lathe headstock. Formerly done by sledge-hammer and brute force, job took 24 man hours. With HOLL-O-RAM job takes only 6½ hours.

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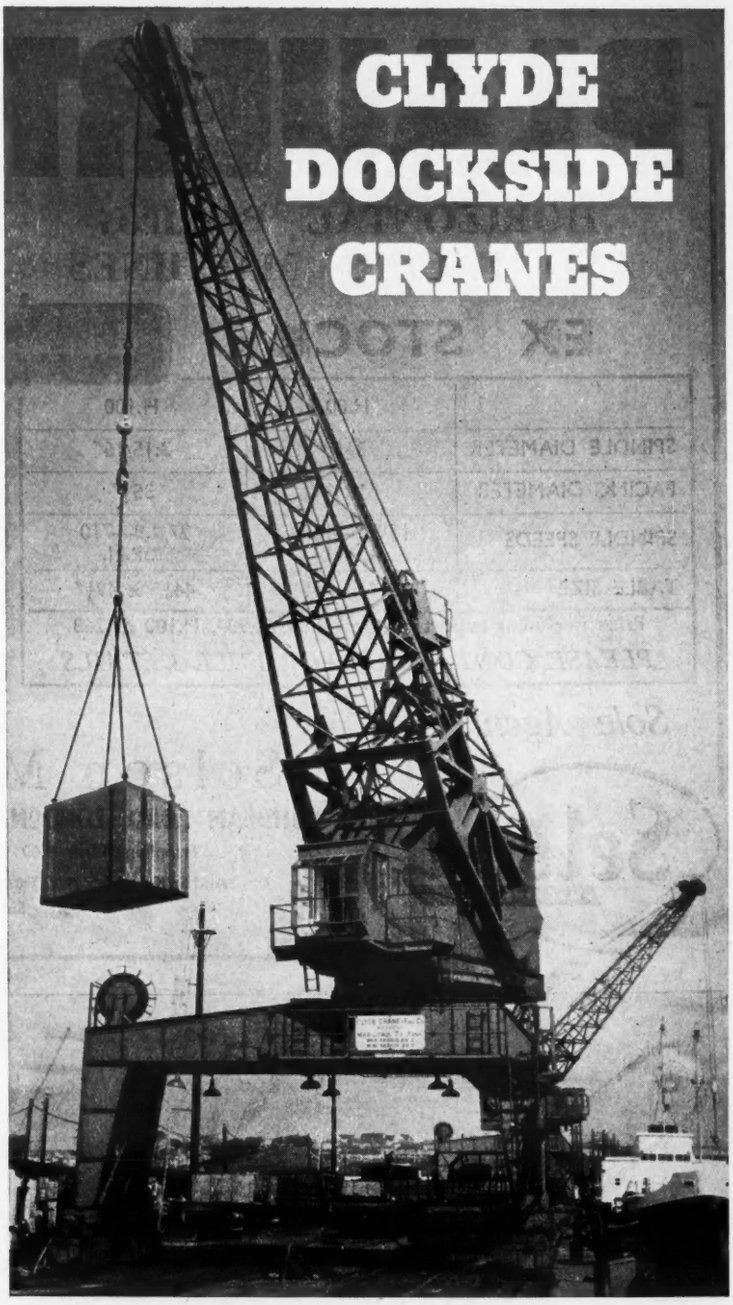

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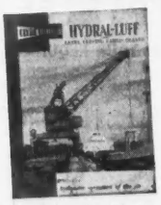

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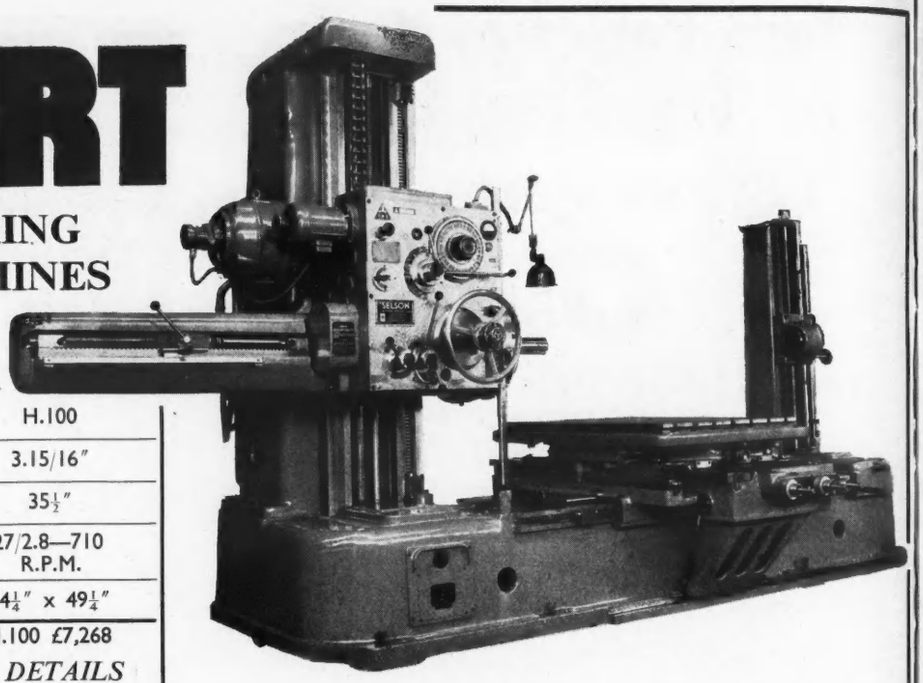

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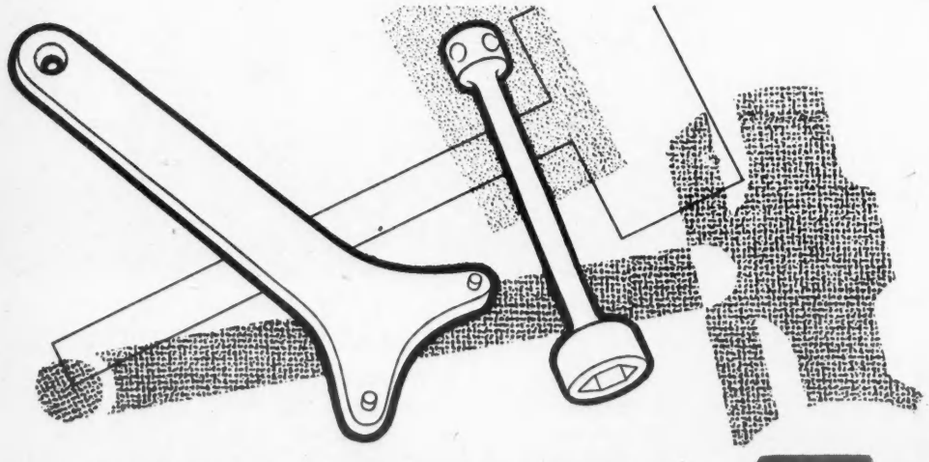

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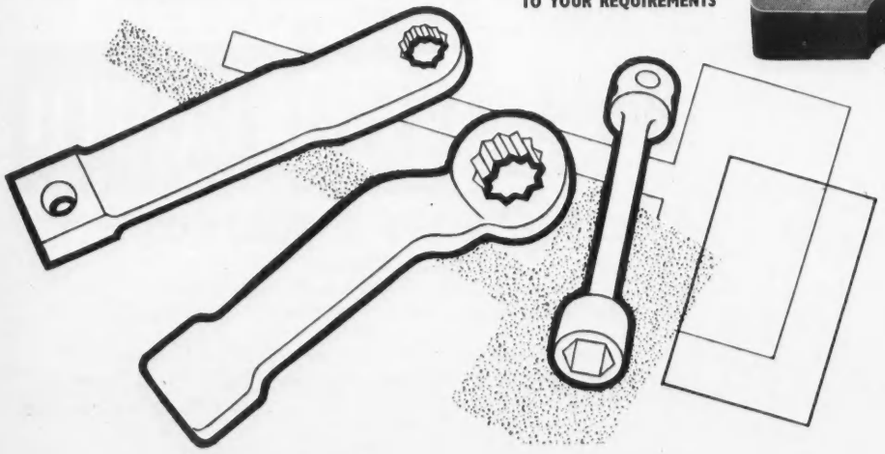

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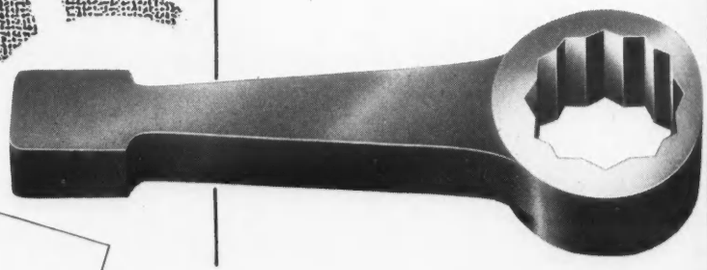

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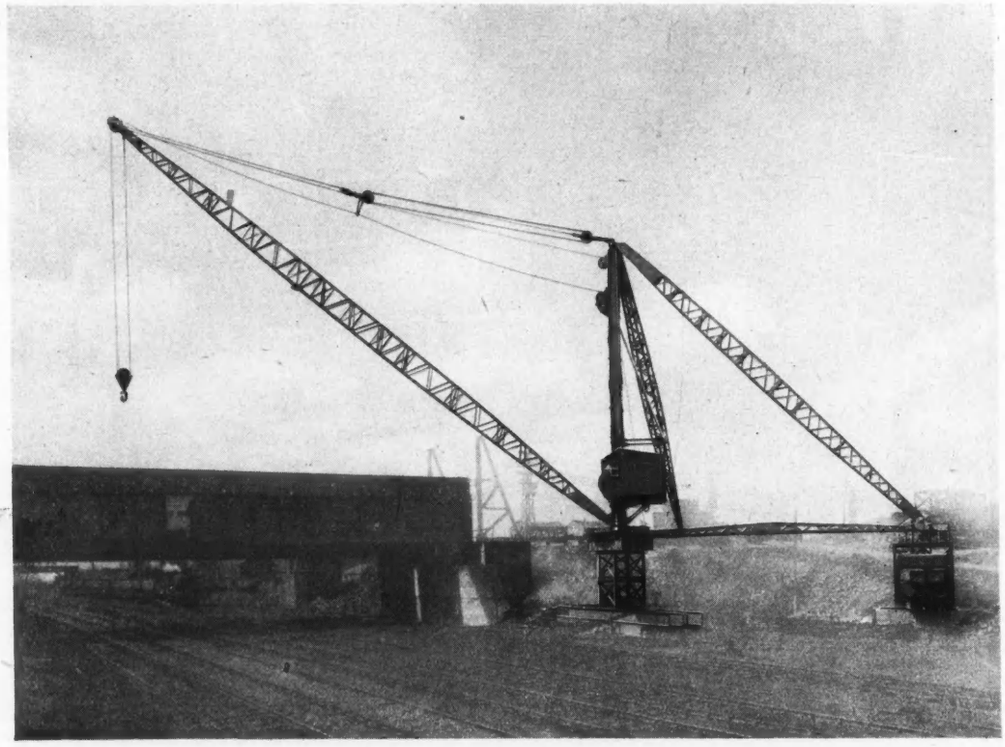

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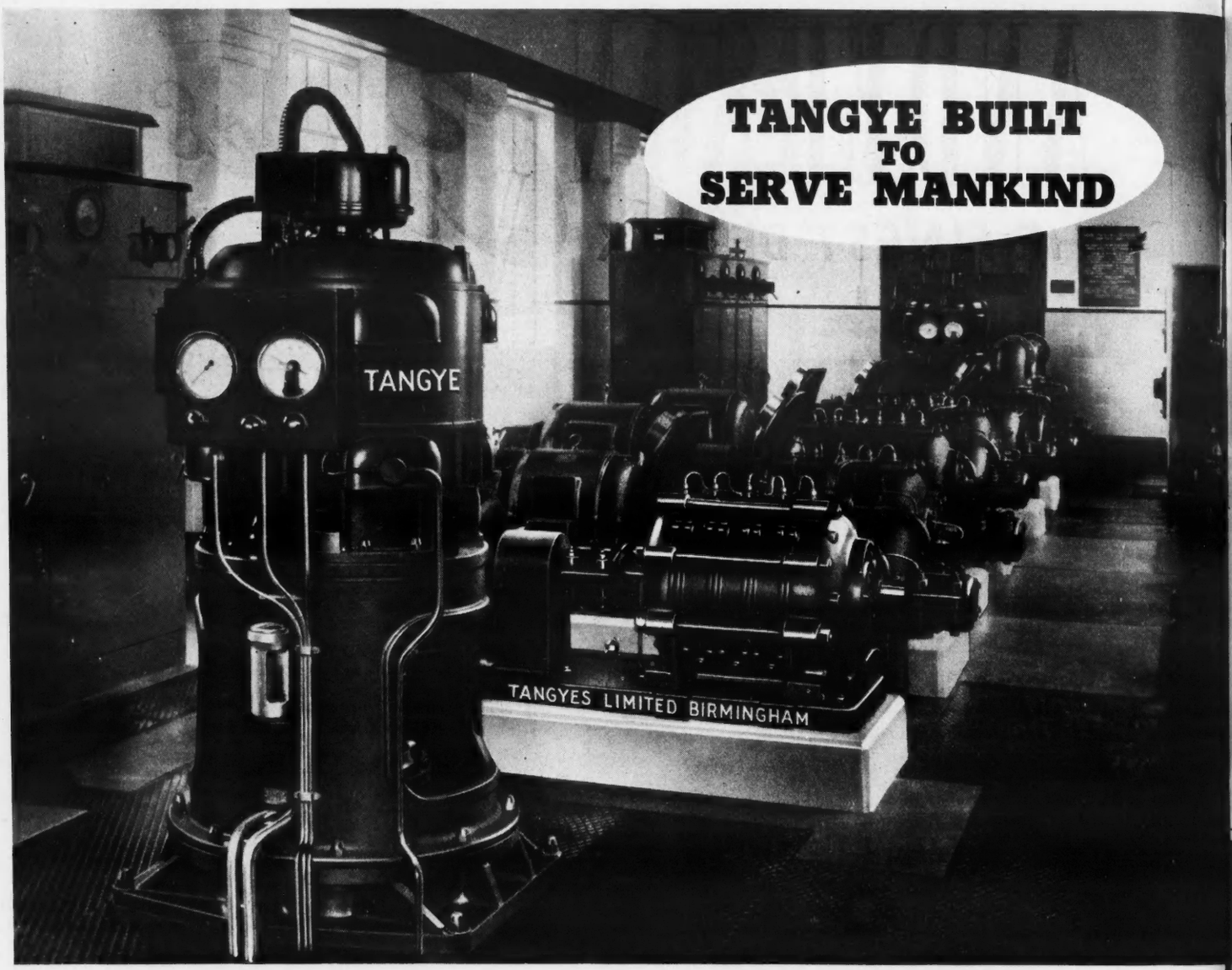

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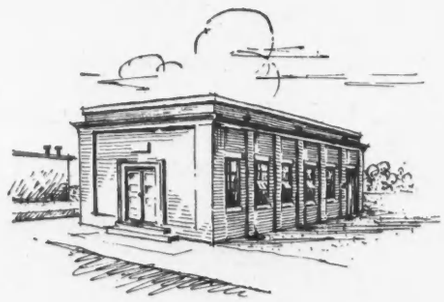

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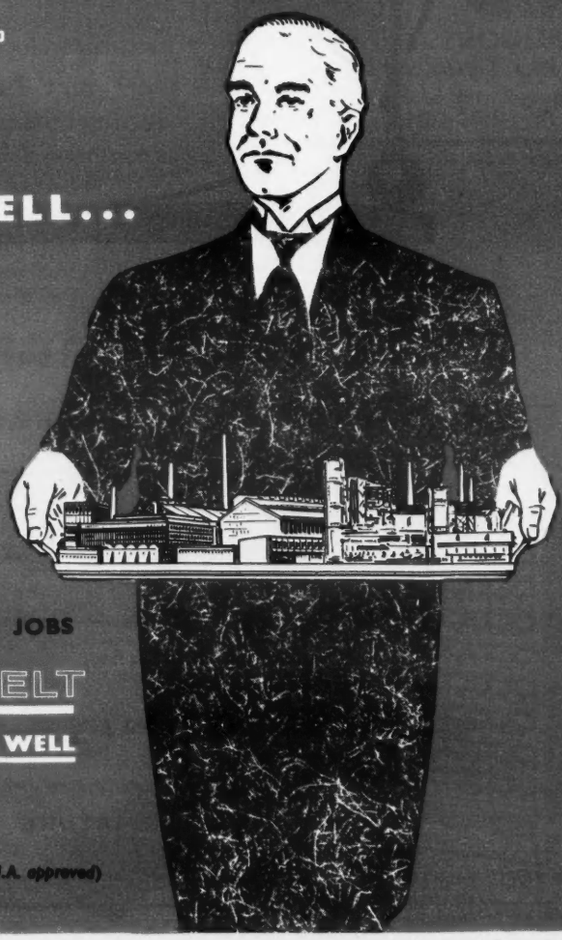

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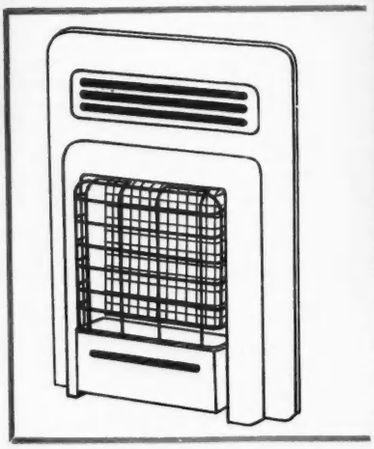

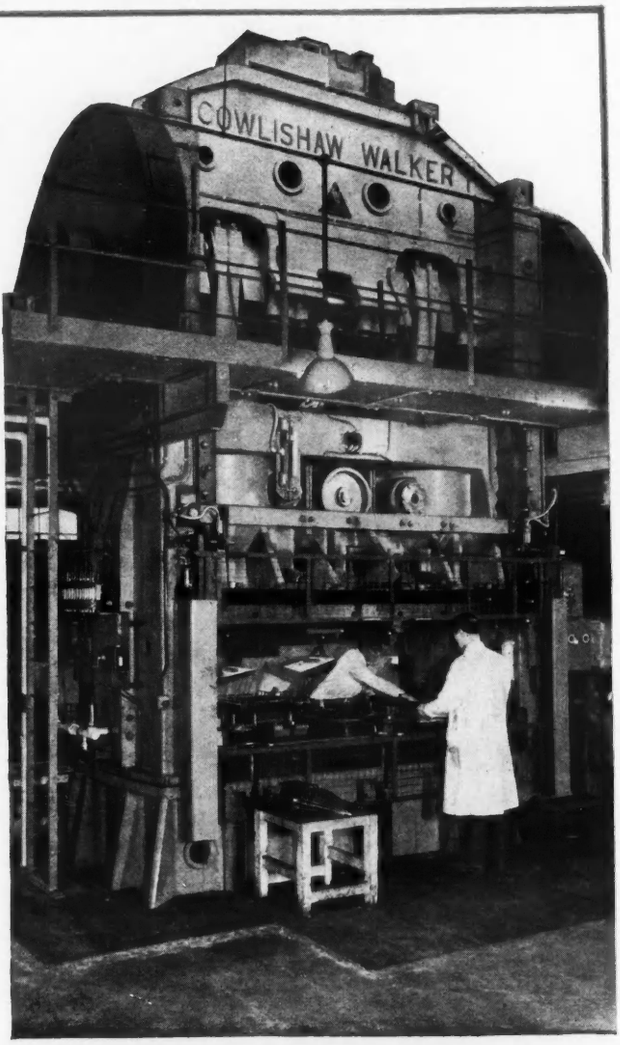

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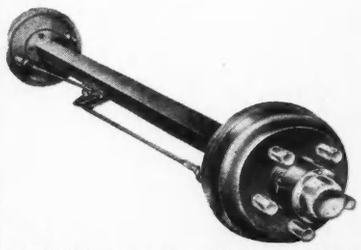

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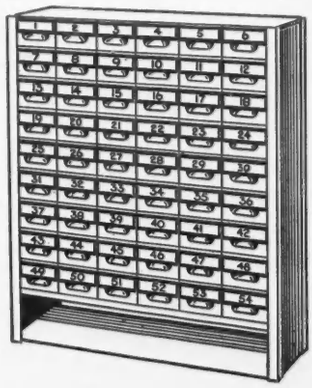

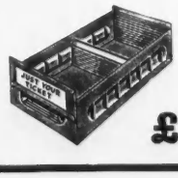

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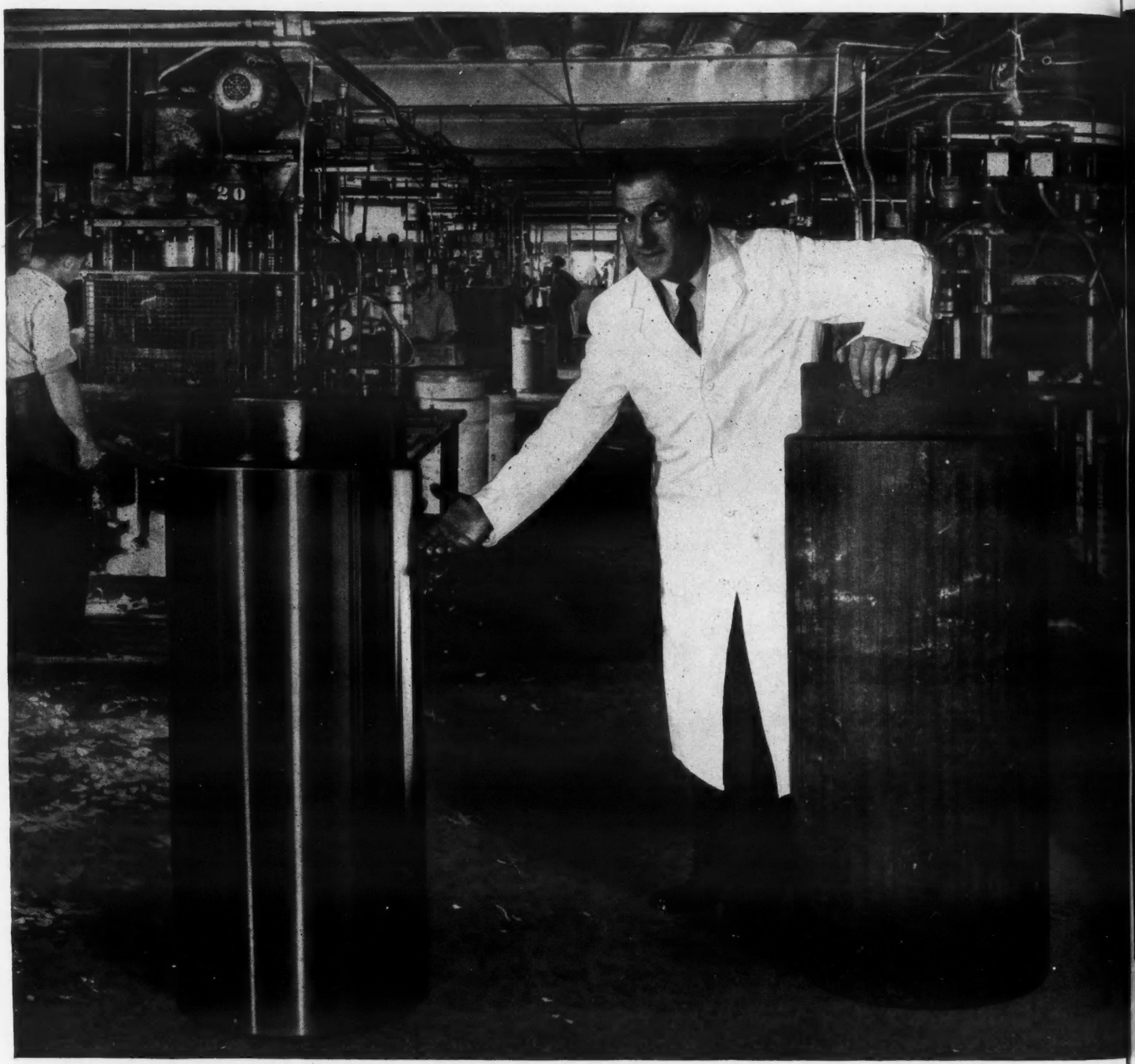

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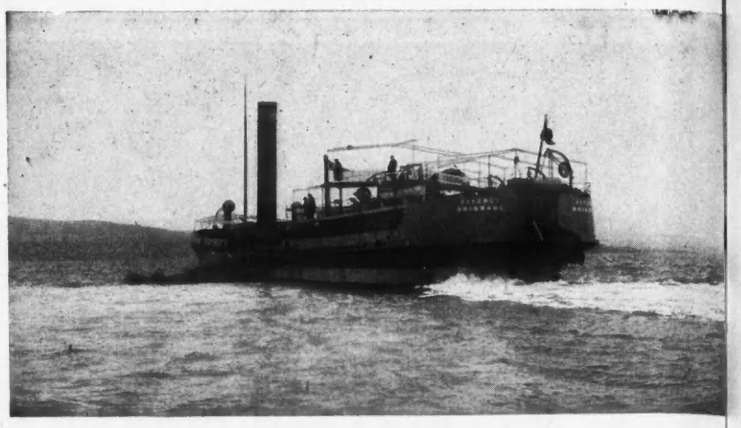

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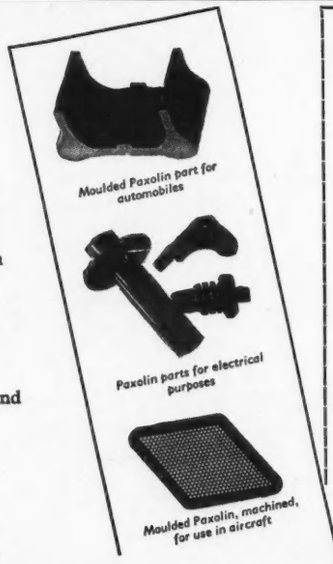
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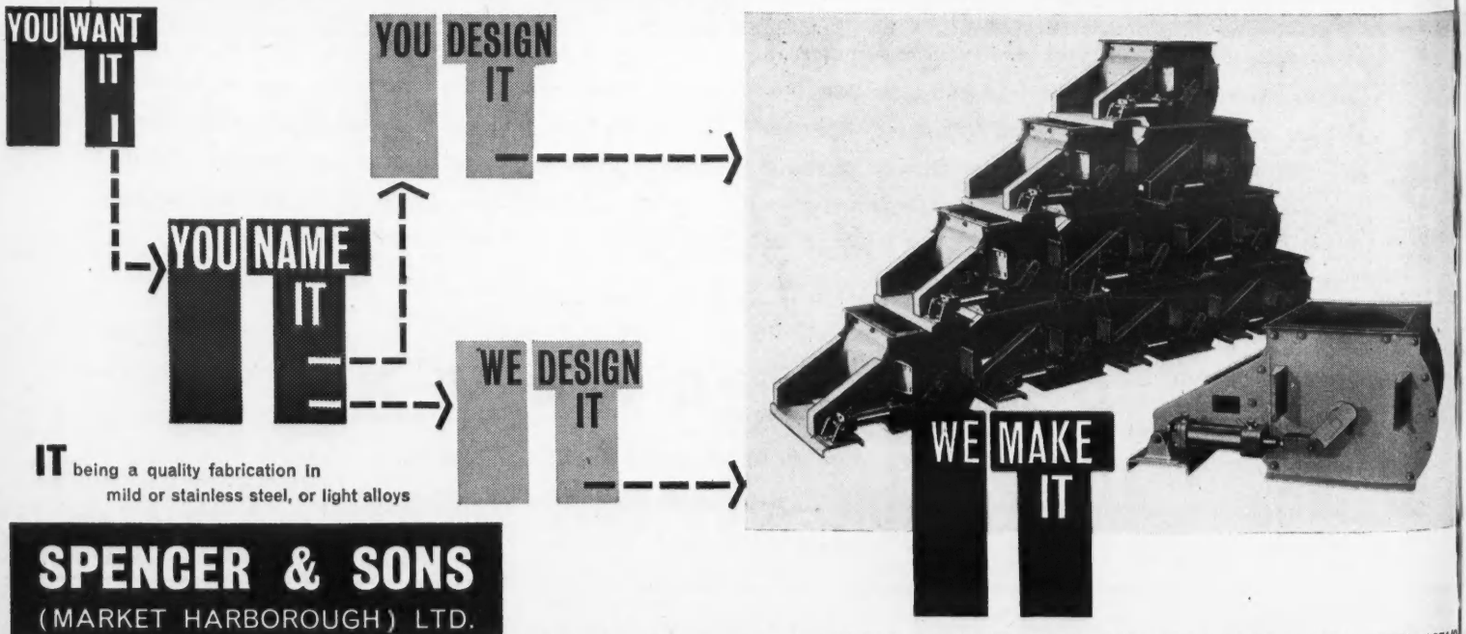

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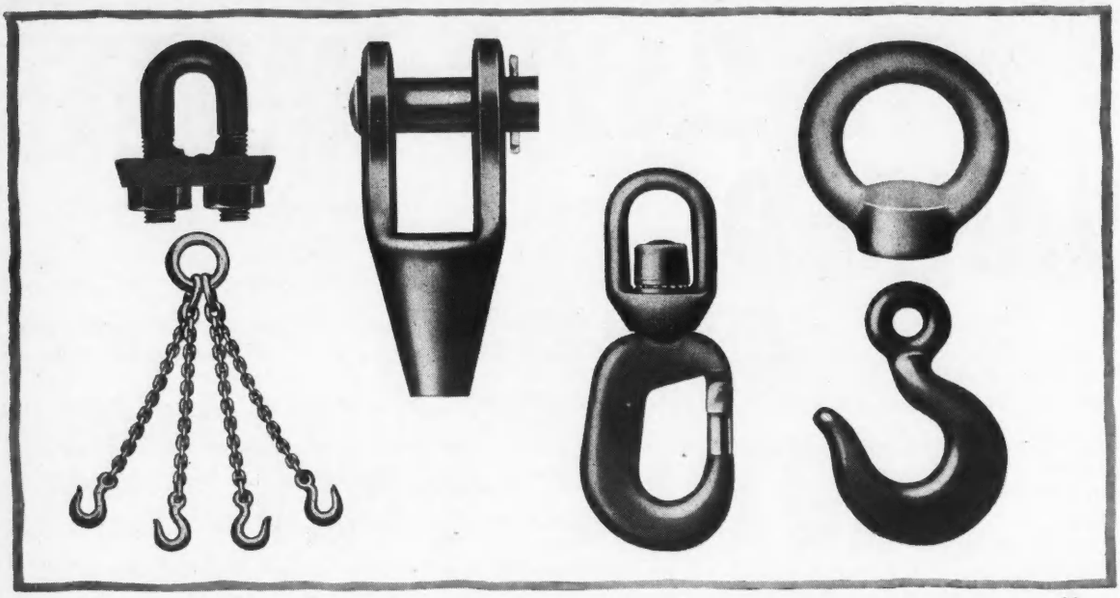

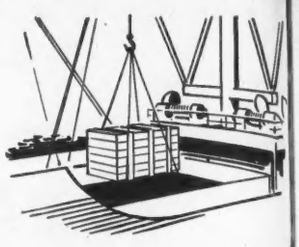

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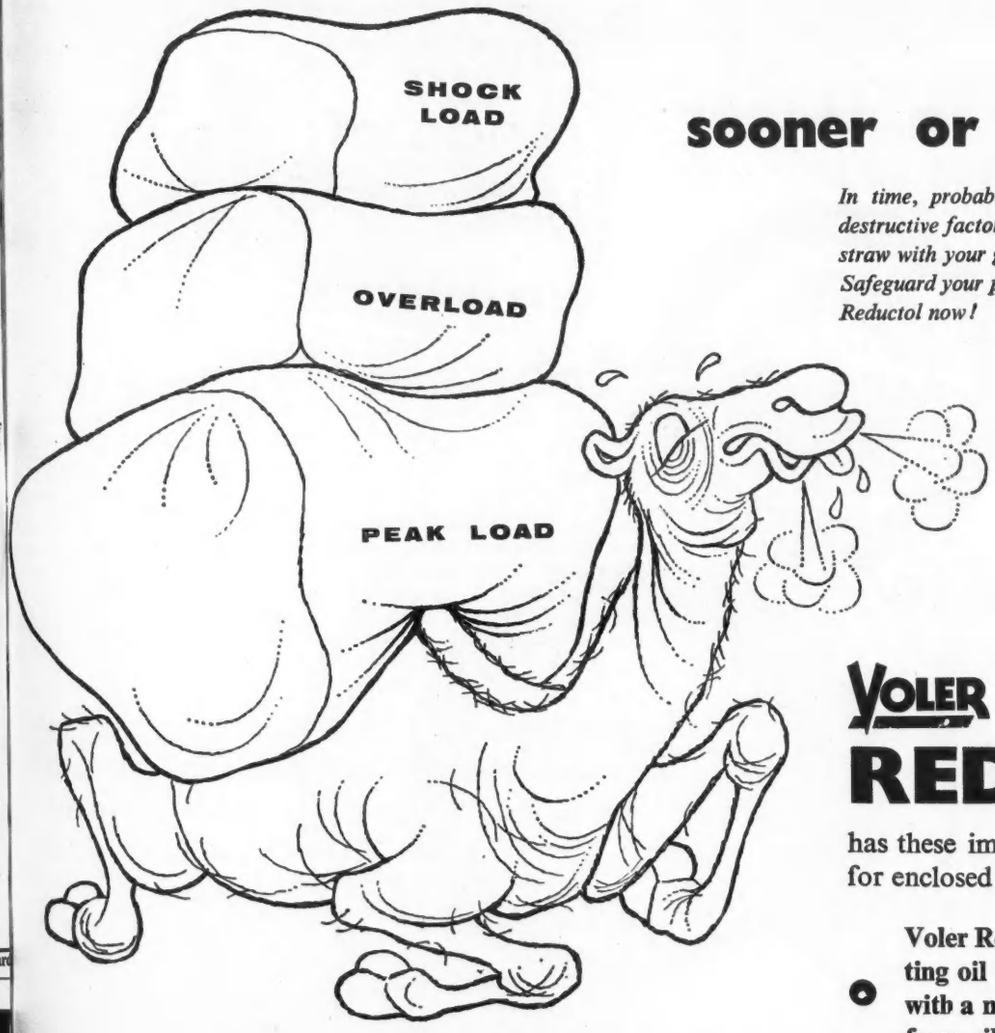

sooner or later . . .

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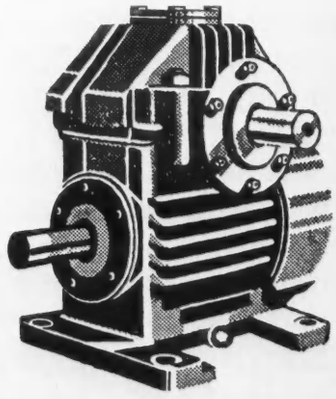

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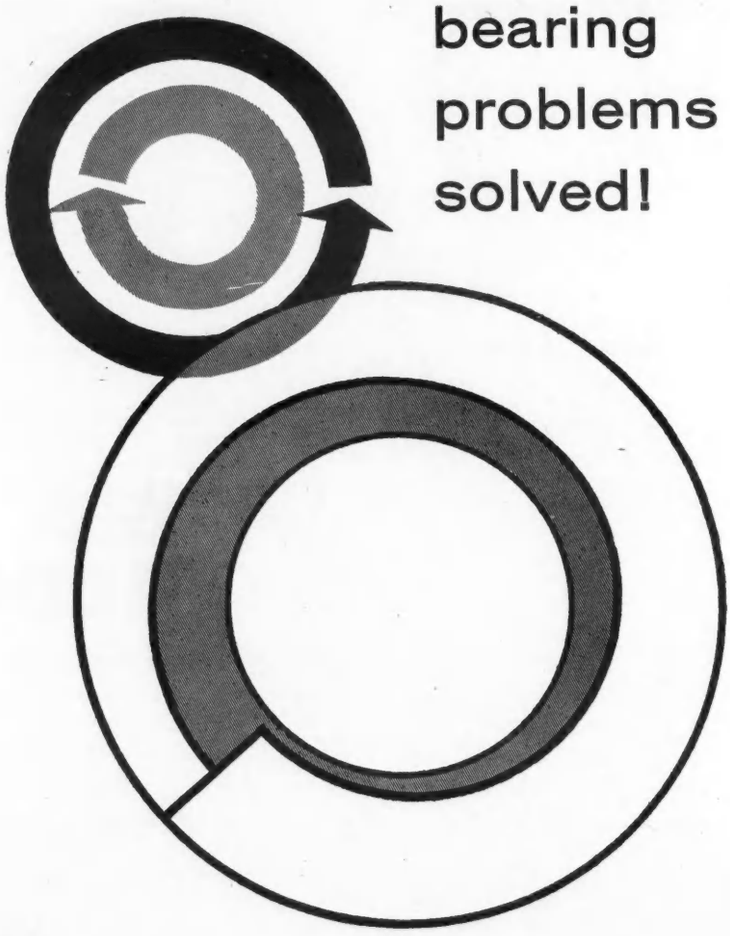

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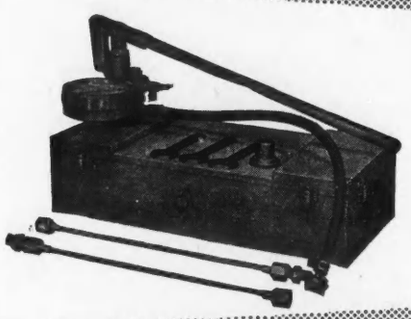

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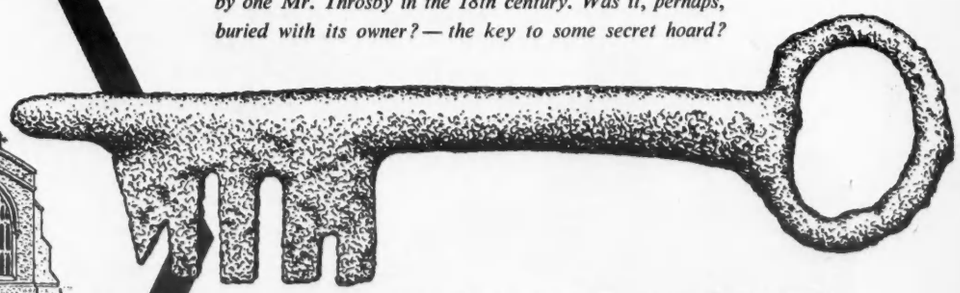
STEEL KEY TO INDUSTRY

No. 33

It is fascinating to speculate on the probable history of this ancient key found in a grave in St. Margaret's churchyard by one Mr. Throsby in the 18th century. Was it, perhaps, buried with its owner? — the key to some secret hoard?



Just as fascinating is the story of steel and its contribution to our modern civilisation. In fact, not only does steel make possible the good and the necessary things of life, it is also the key that will open the door of the future. Hallamshire high grade alloy and carbon steels are helping to build that future *today!*

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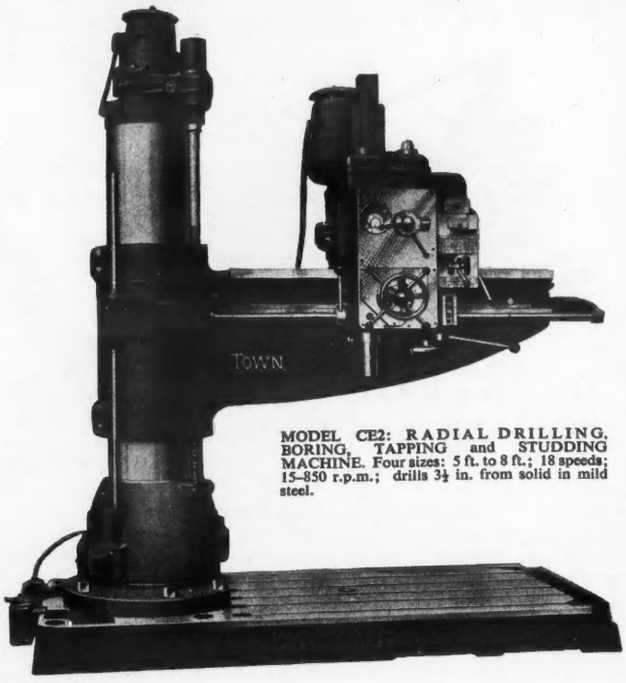
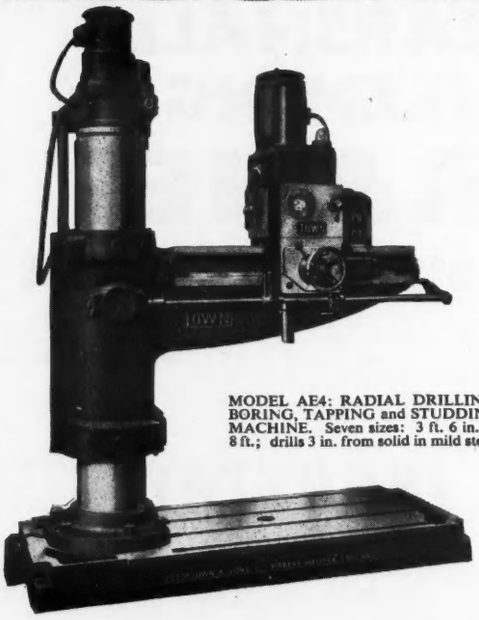
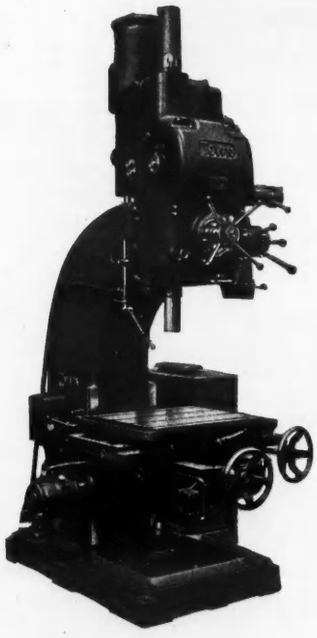


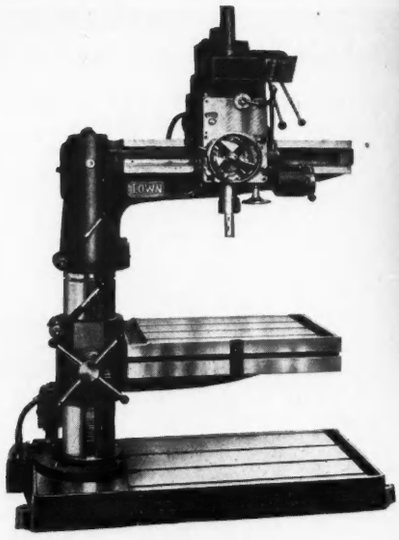
MODEL CE2: RADIAL DRILLING, BORING, TAPPING and STUDDING MACHINE. Four sizes: 5 ft. to 8 ft.; 18 speeds; 15–850 r.p.m.; drills 3½ in. from solid in mild steel.



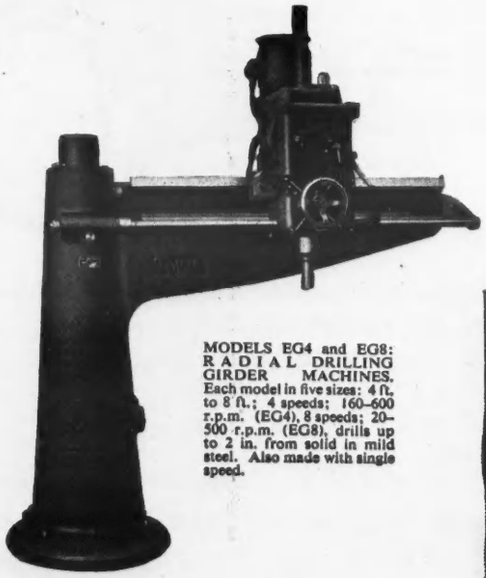
MODEL AE4: RADIAL DRILLING, BORING, TAPPING and STUDDING MACHINE. Seven sizes: 3 ft. 6 in. to 8 ft.; drills 3 in. from solid in mild steel.



MODEL AE2: VERTICAL DRILLING MACHINE (heavy-duty model). Two sizes: 36 in. and 42 in.; drills 3½ in. from solid in mild steel.



MODEL AE5: RADIAL DRILLING, TAPPING and STUDDING MACHINE. 42 in.; drills 1½ in. from solid in mild steel or 1½ in. in cast iron.



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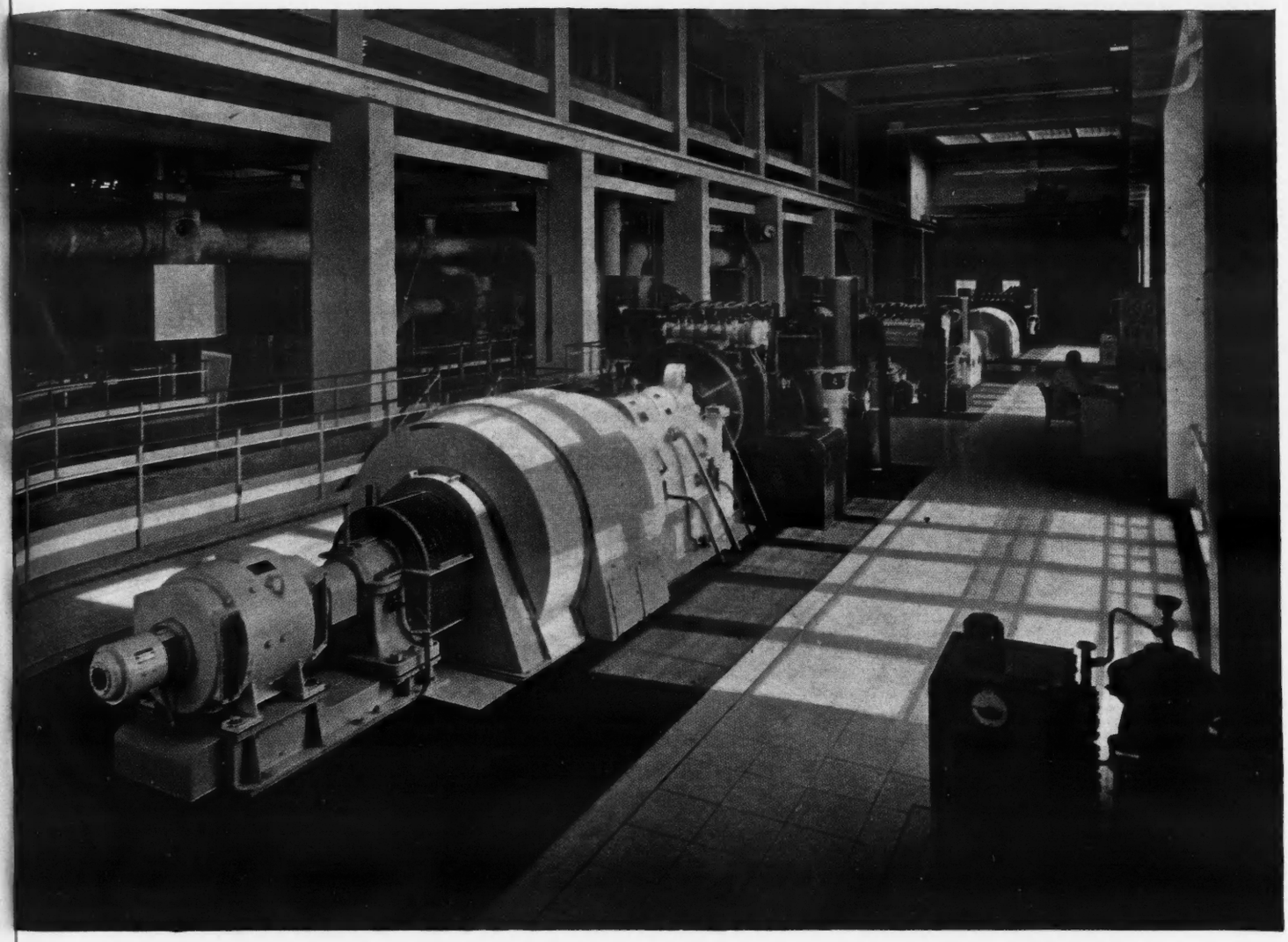

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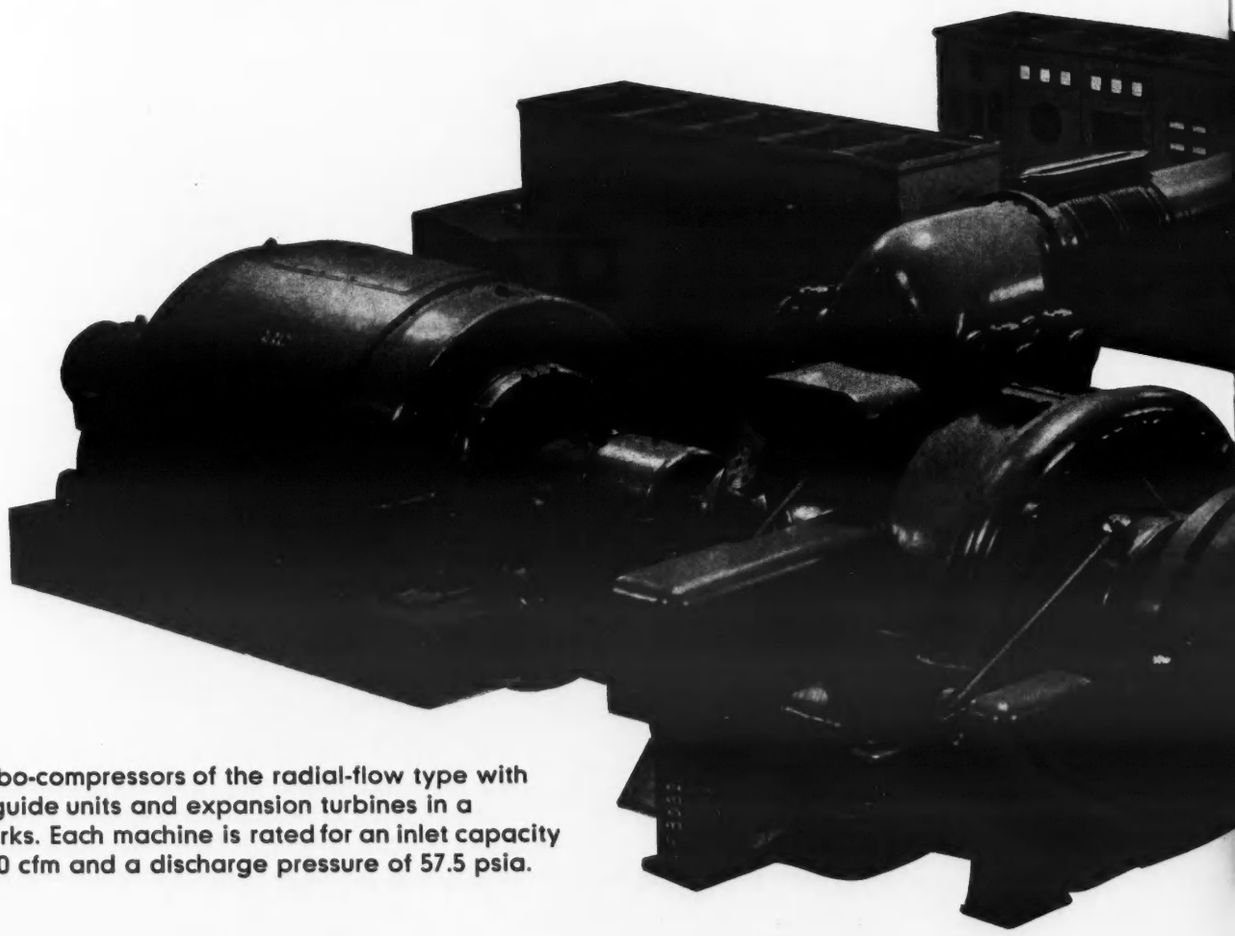

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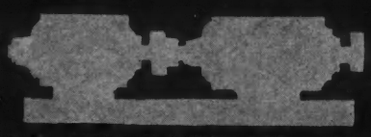
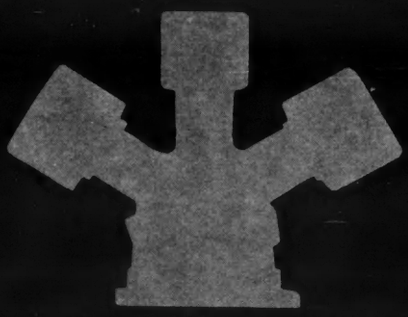
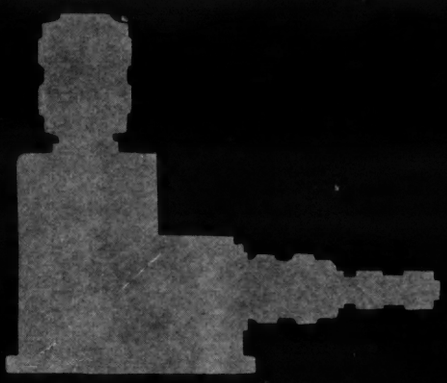


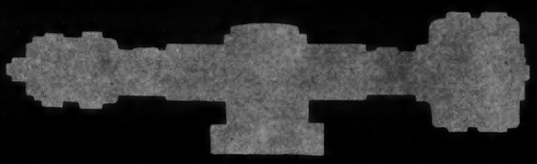
Rotary Compressors



Reciprocating Compressors of the V-and W-Type



Reciprocating Compressors of the L-Type



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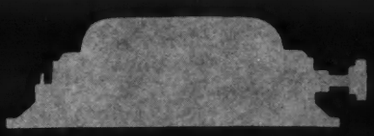

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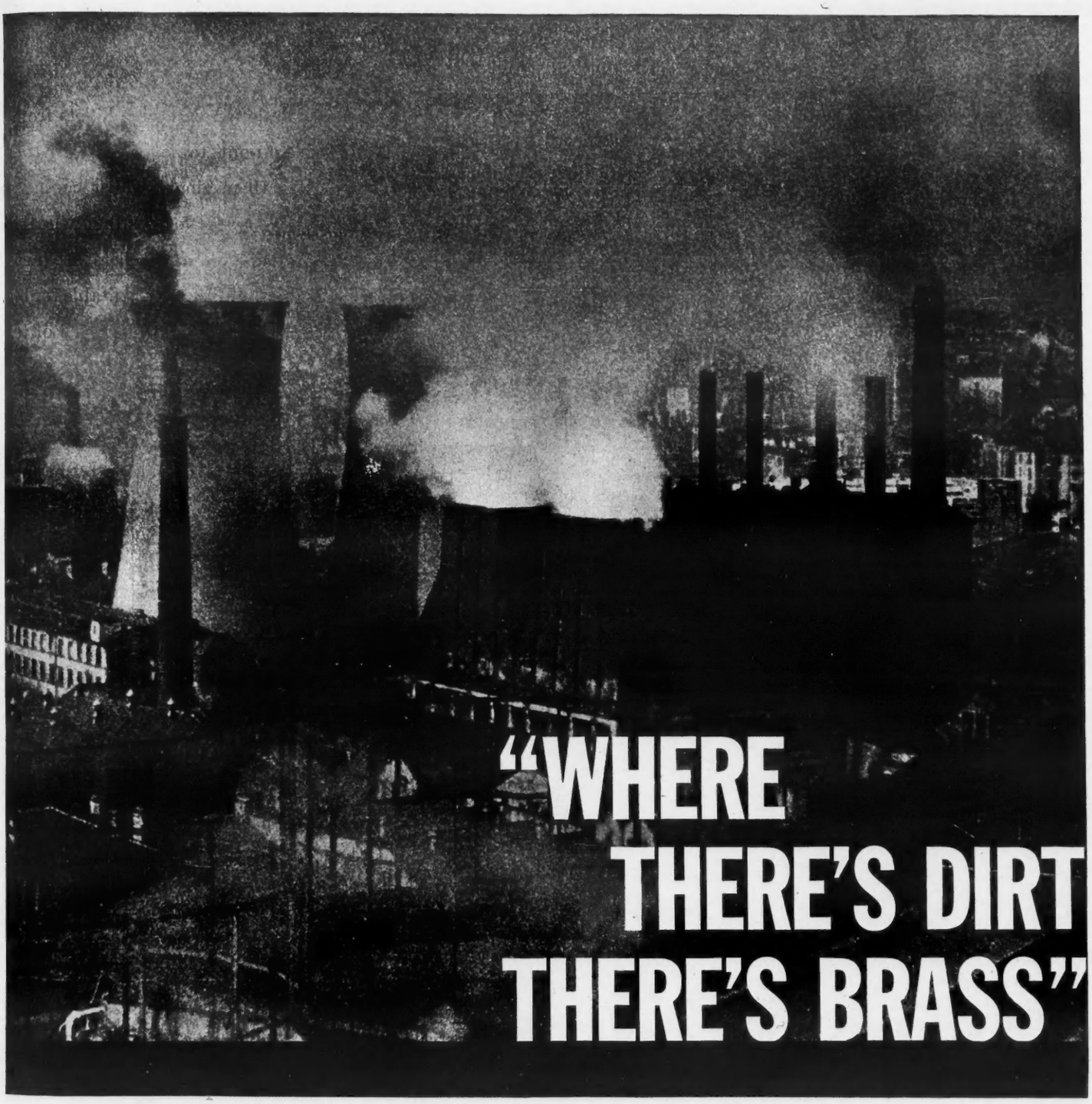

Where there's dirt there's brass was an accepted truth among our grandfathers, but today it is recognised that dirt in any form is the result of inefficiency.

Smoking chimneys mean inefficient combustion. Dust emission from process plants may mean waste of a valuable product. Any fouling of the atmosphere may damage goodwill of neighbours.

In almost every case, money spent on prevention of atmospheric pollution can be recovered in a comparatively short time.

The Buell Engineering Co. Inc. of New York has long been one of the leading companies in the world in this field of activity and in 1959 they established a subsidiary in England trading under the name of AMBUCO to operate throughout the non-dollar area. Both these companies are wholly owned subsidiaries of Consolidated Gold Fields of South Africa Ltd.

Buell Engineering recently absorbed the Northern Blower Co. of Cleveland, Ohio, who manufacture the Norblo fabric dust arrester. This also is now available through the Ambuco organisation.

HIGHLY QUALIFIED TECHNICAL STAFF

The technical staff of AMBUCO are not only dust control specialists, but include highly qualified engineers from those industries which they will serve. Thousands of their dust collectors are already in use all over the world in industries such as steel, chemicals, cement, petroleum, fertilizers, power plants, etc.

Ambuco will handle all forms of dust control equipment. For the time being their specialised equipment will be:—

1. *The Ambuco high efficiency cyclone for the collection of finest dusts and powders.*
2. *The Ambuco low draught loss grit arrester for all types of boiler plants.*
3. *Ambuco high efficiency automatic fabric dust arrester.*

ALL AMBUCO EQUIPMENT HAS THESE OUTSTANDING FEATURES

** Guaranteed efficiency based on actual operating conditions. * Highest possible collection efficiency. * Lowest possible power consumption. * Lowest possible maintenance costs. * All equipment specially designed to process requirements.*

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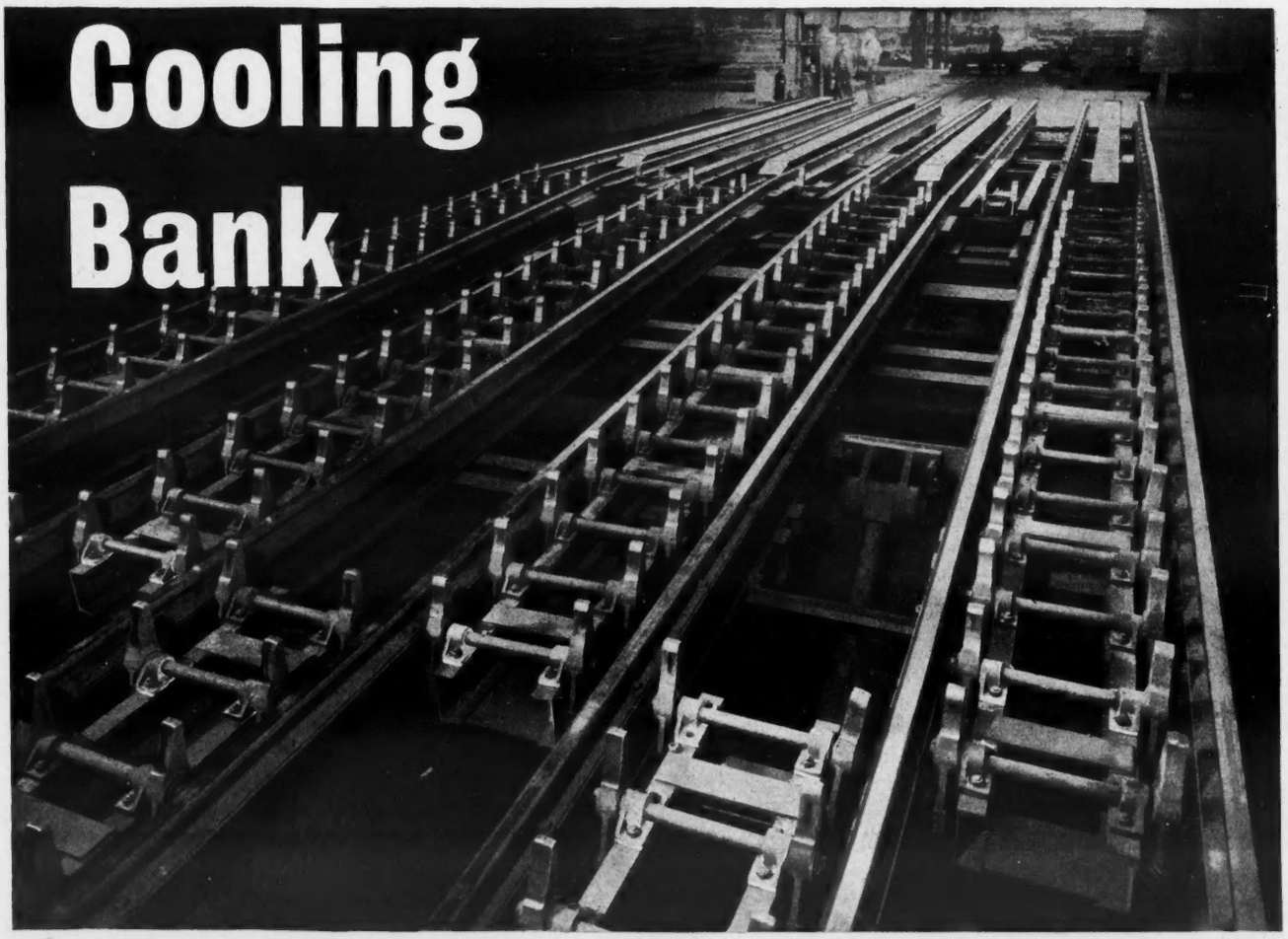

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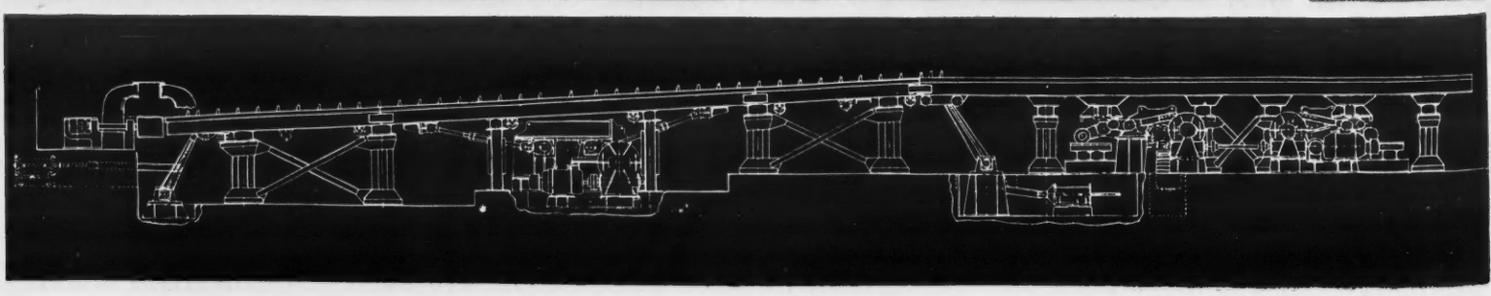

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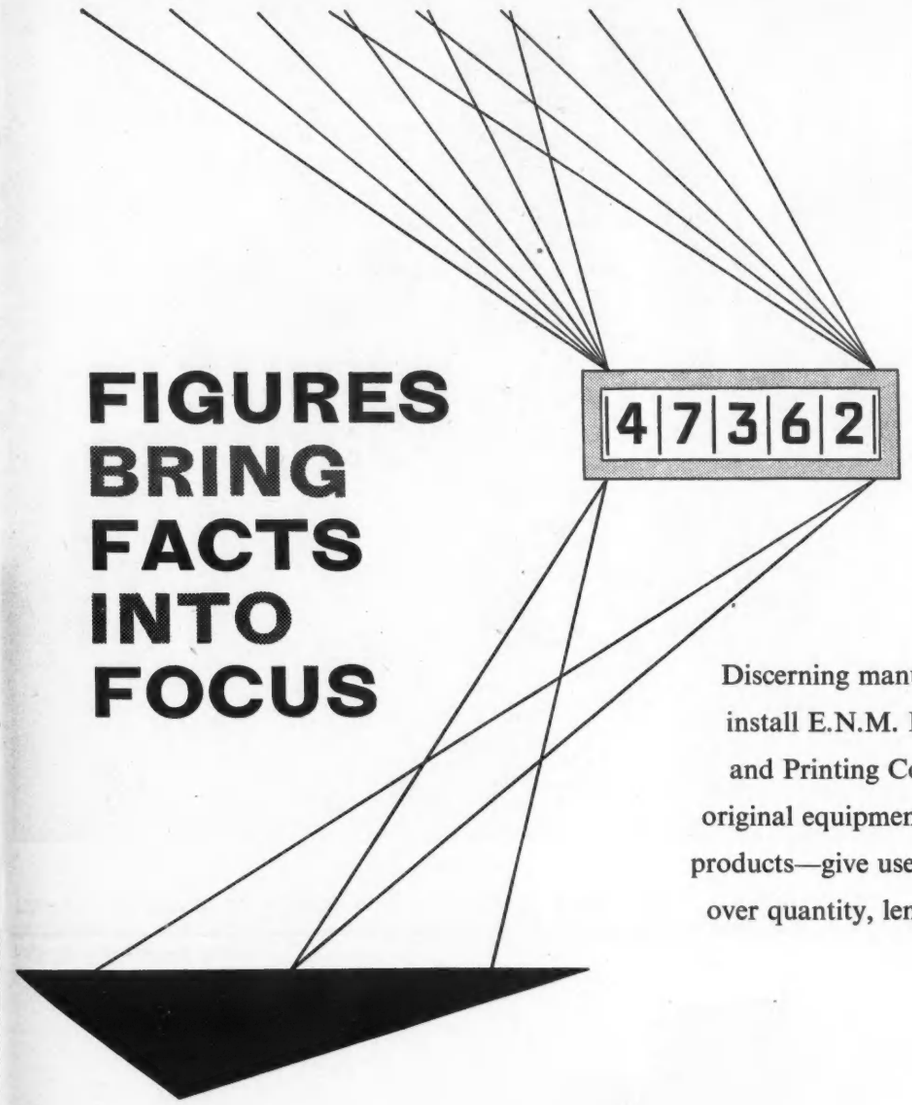

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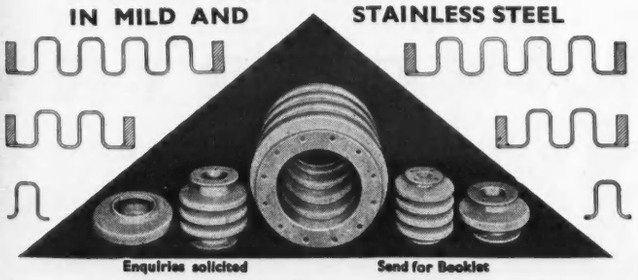

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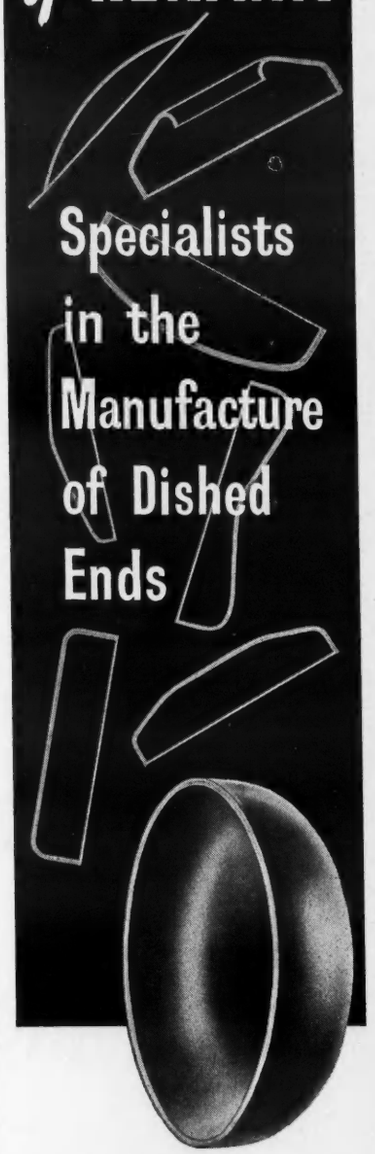

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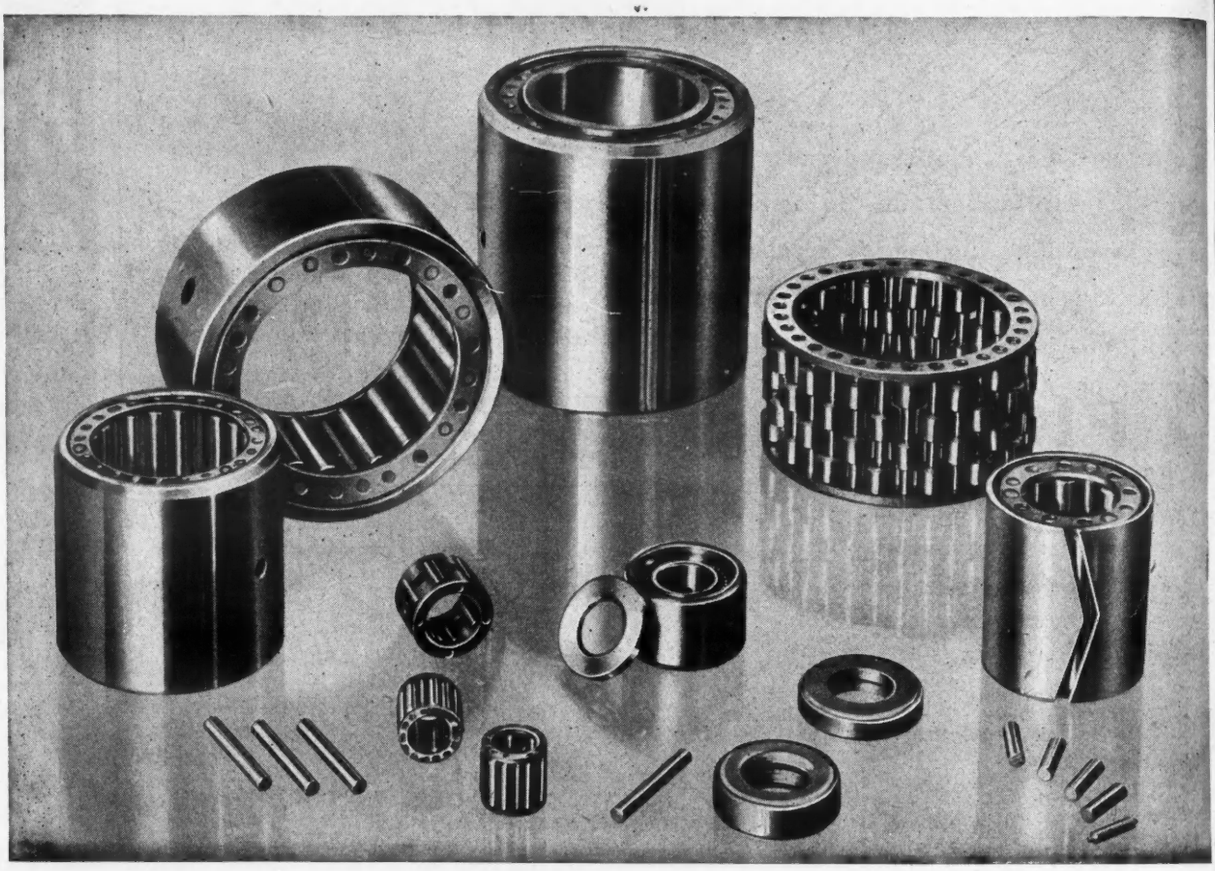

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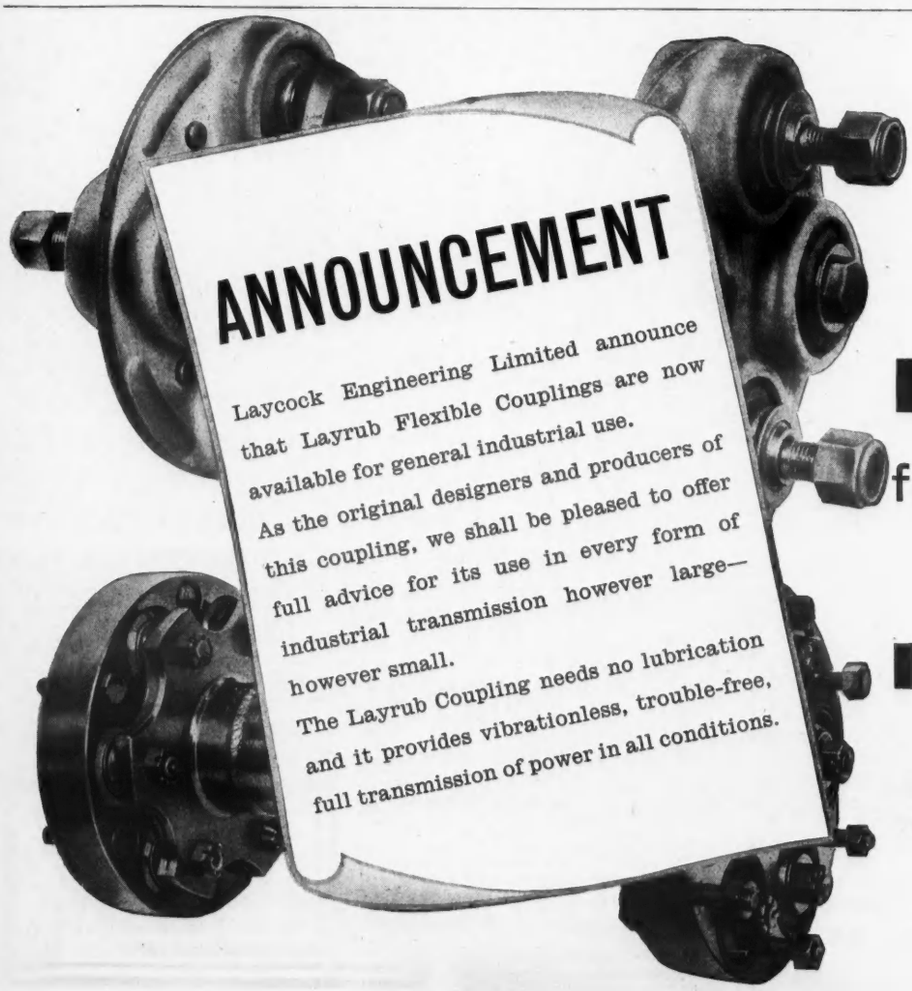
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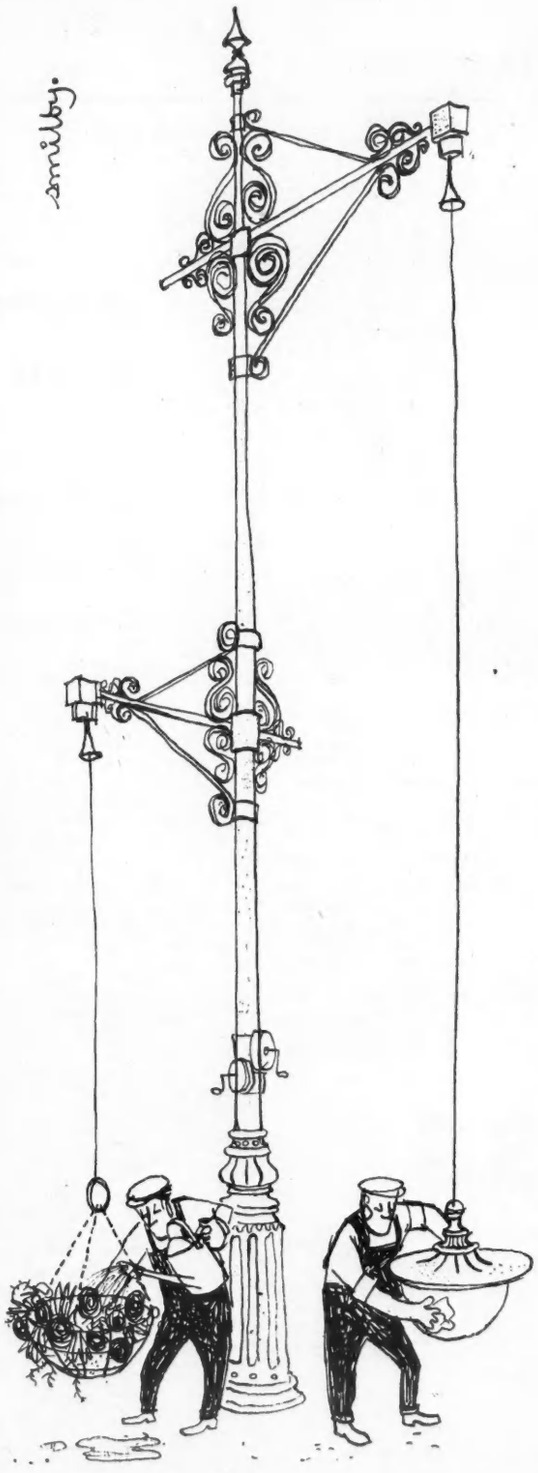

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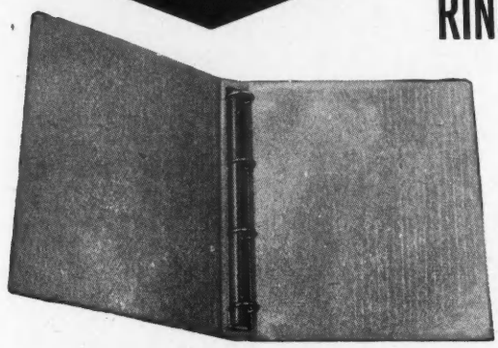

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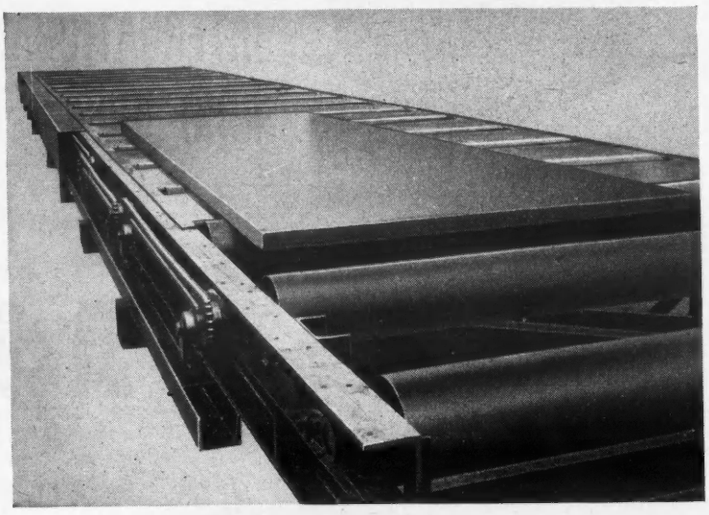

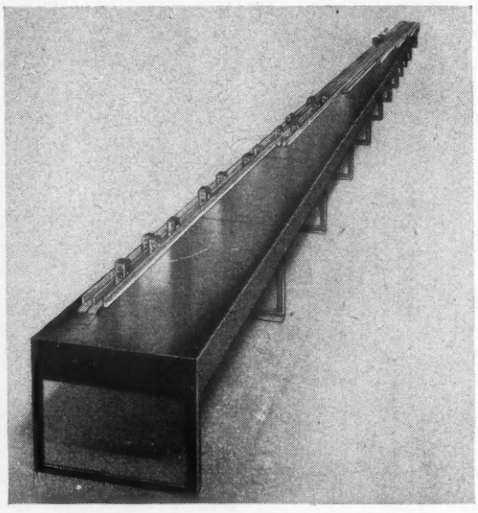

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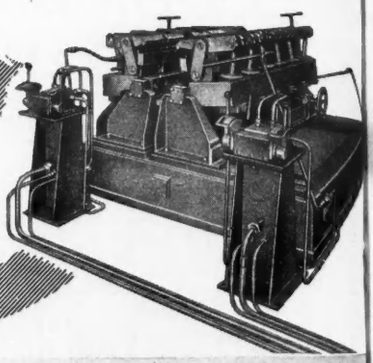
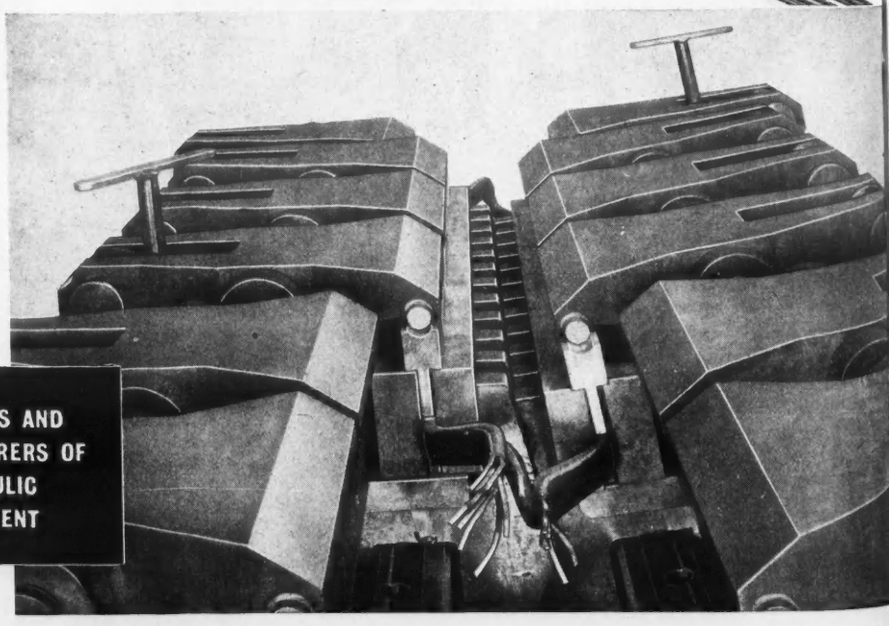


Specially developed for the electrical industry, the press illustrated is one example of the variety of machines we supply to customers' requirements.



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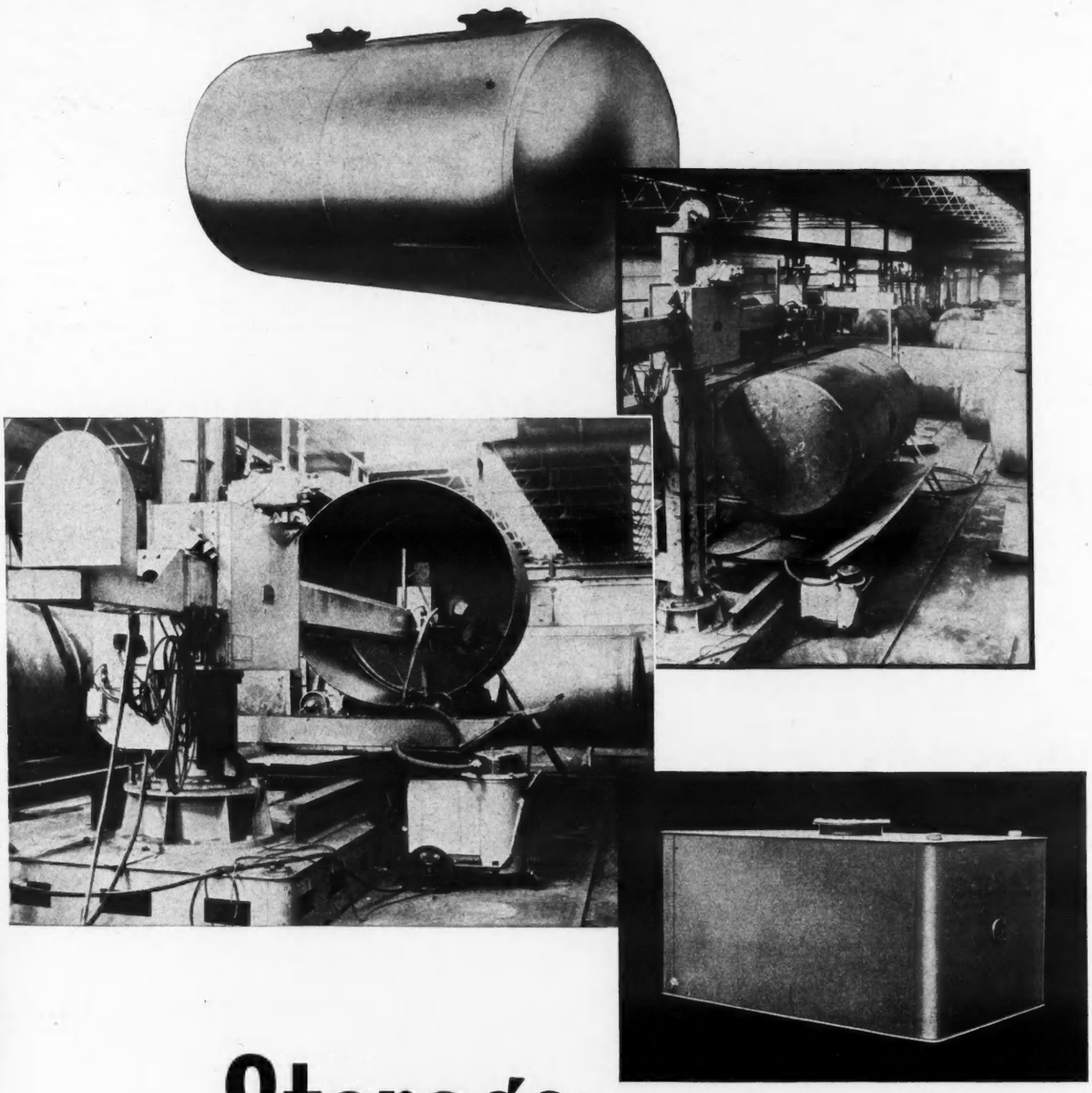

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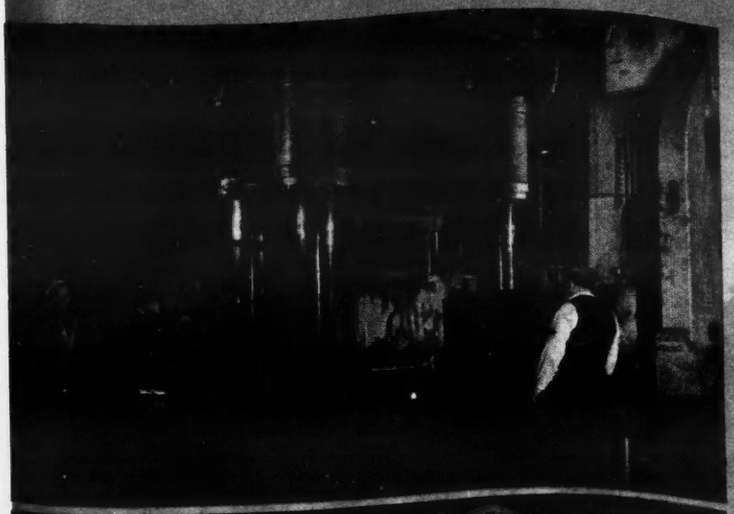

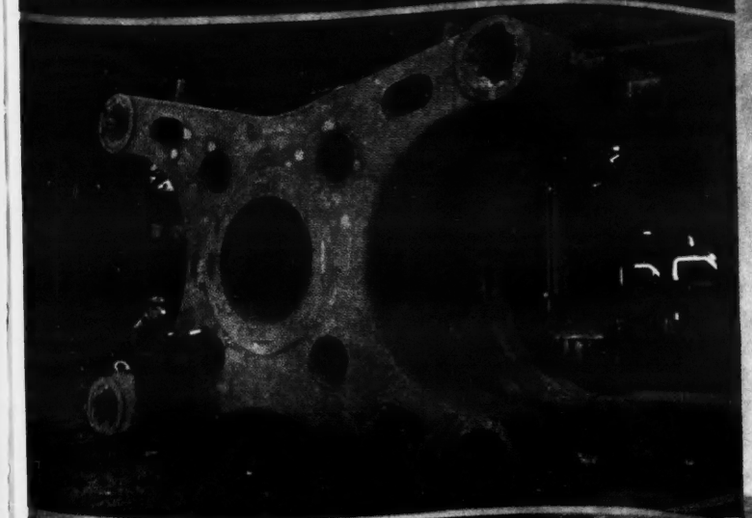

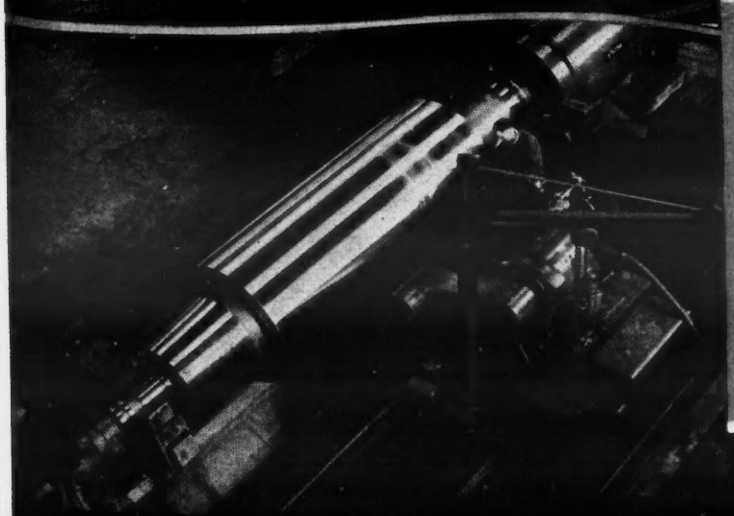

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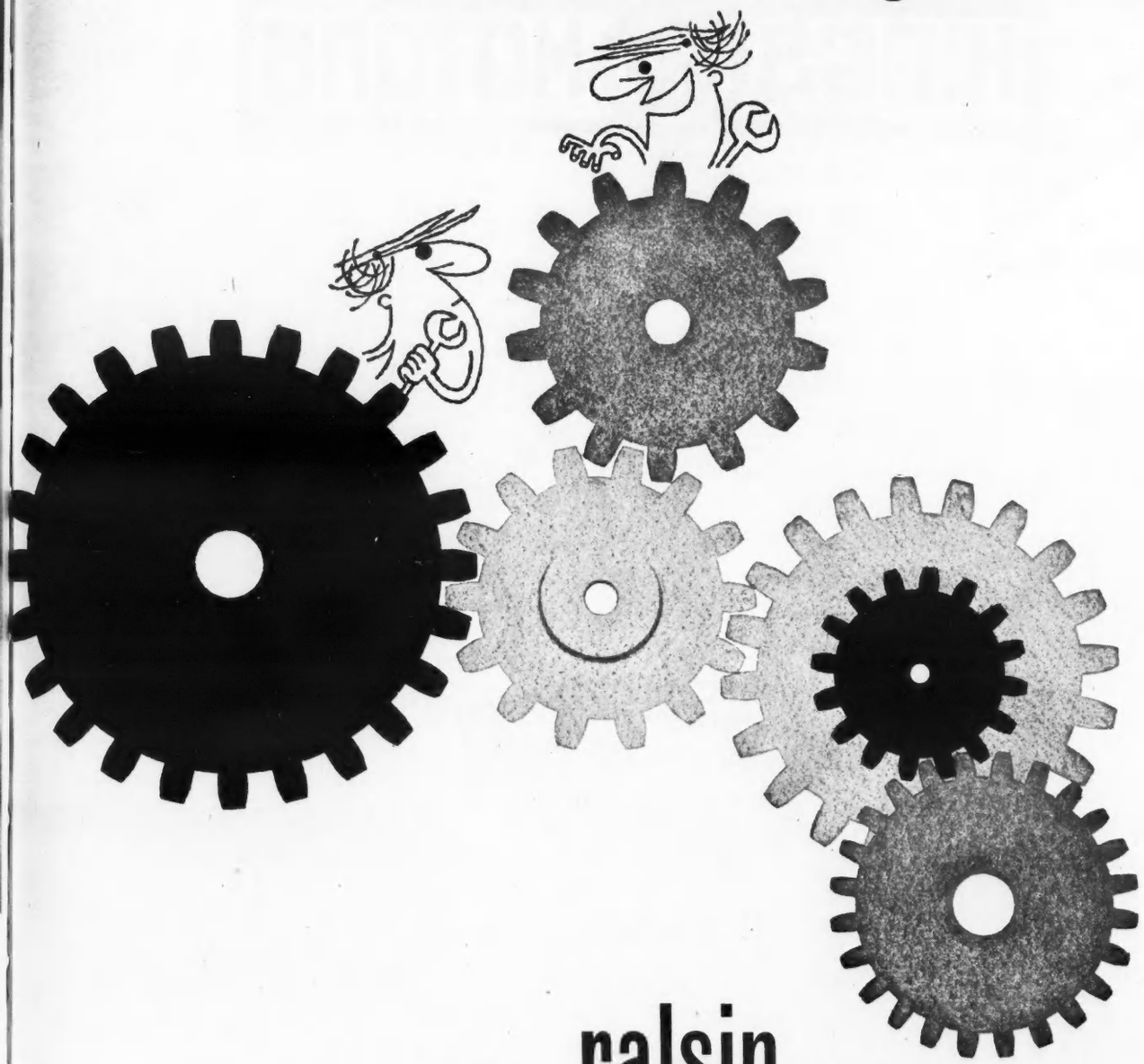

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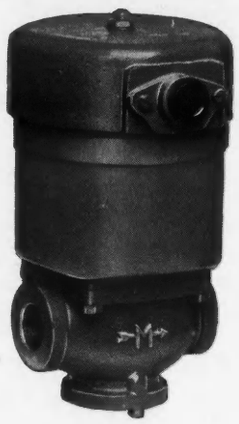

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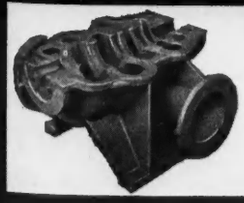
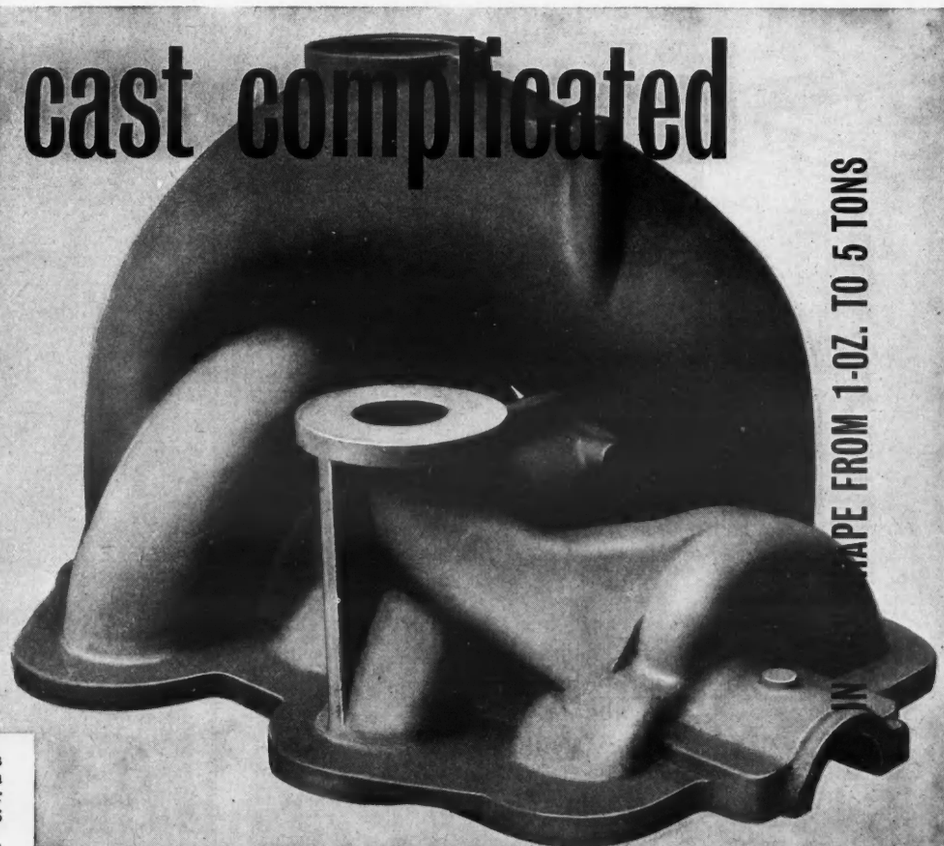


Large illustration shows a Shipham casting for a Centrifugal Pump Cover —overall length 4' 0"; weight 1330 lbs. Alongside—Centrifugal Pump Body — overall length 4'0"; weight 2425 lbs.

cast complicated



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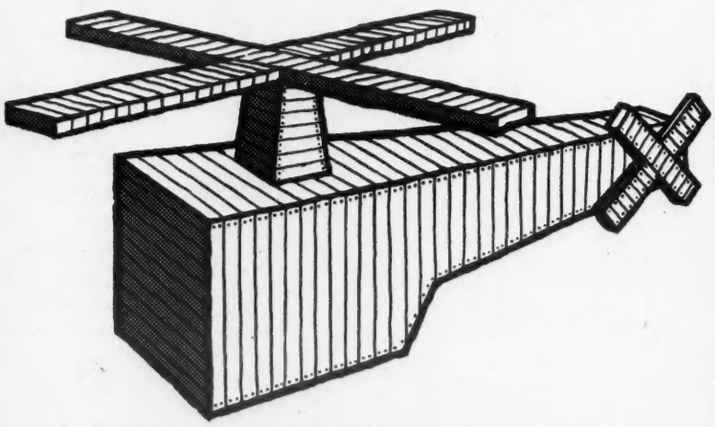

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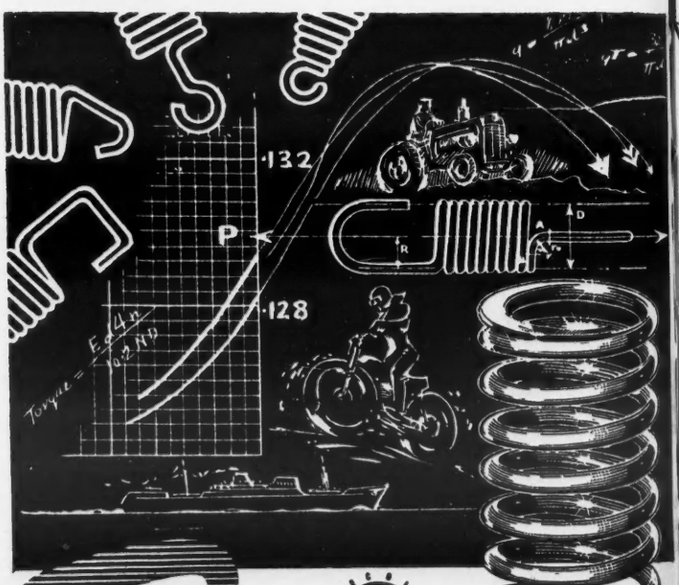

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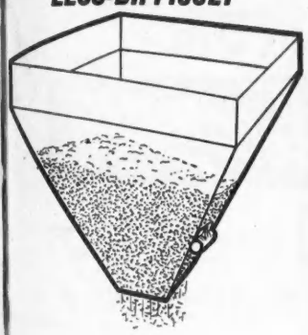

The installation of an external vibrator to a steel hopper.

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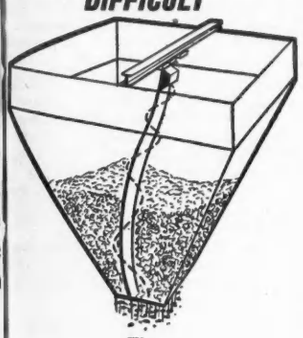

The vibrating reed for application where external vibration is impractical due to structural or other difficulties and if the bunker is made of concrete.

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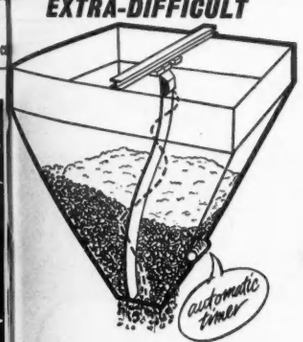

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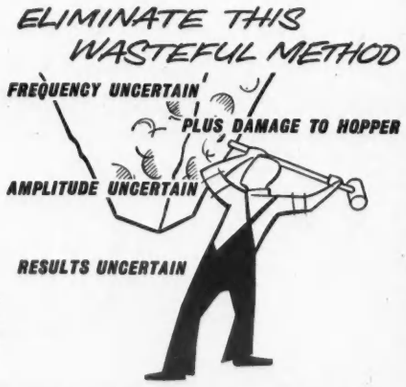

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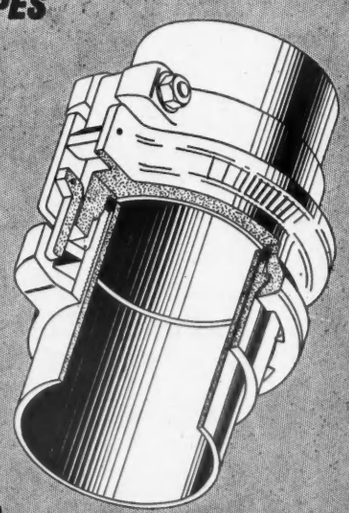

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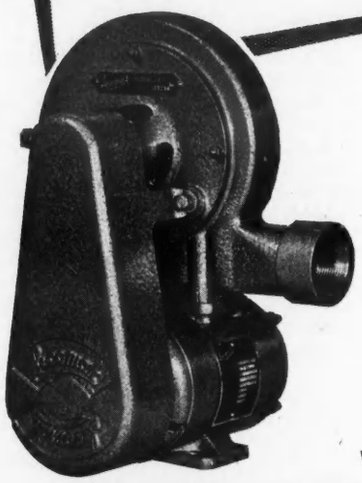

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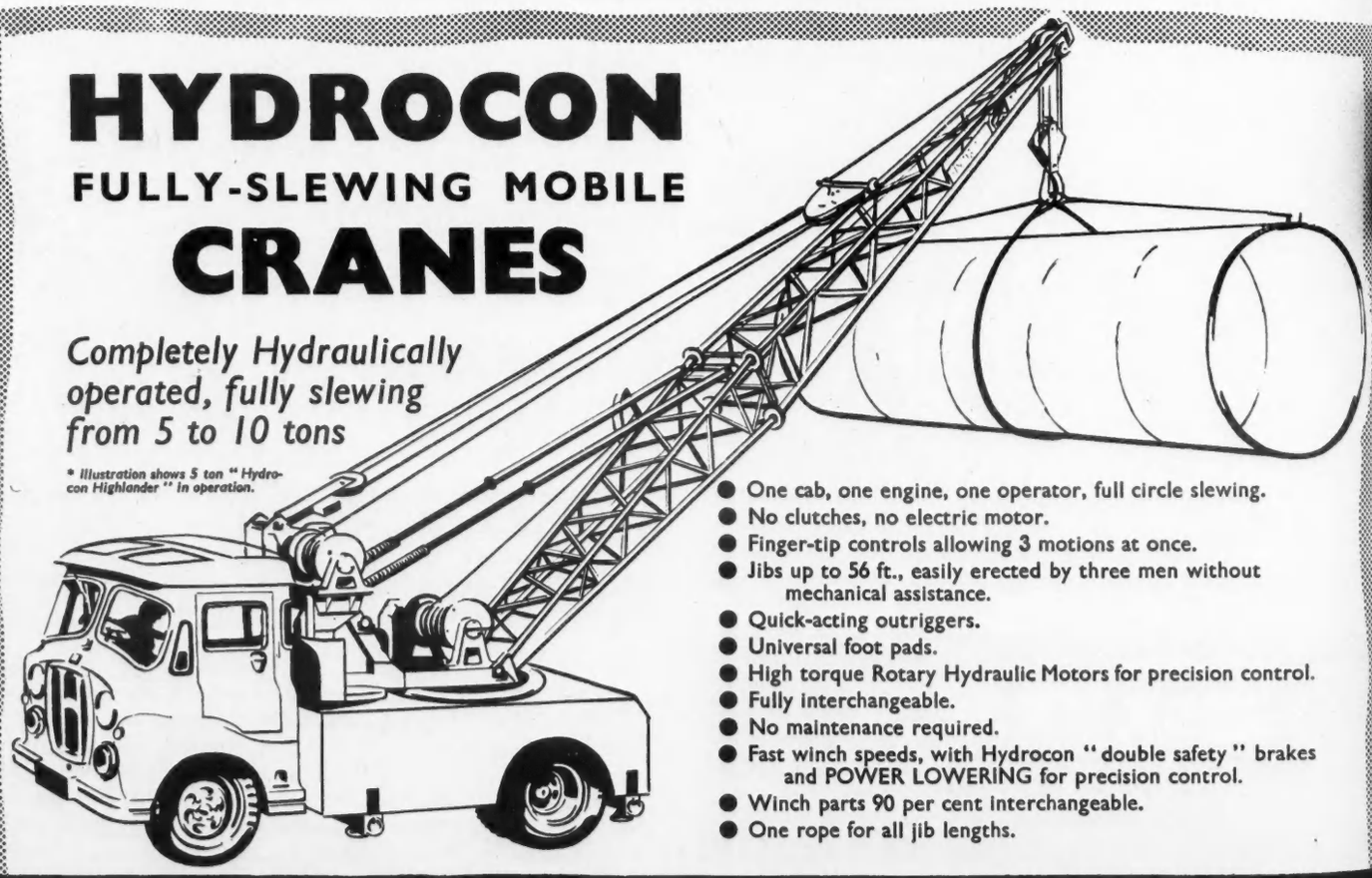

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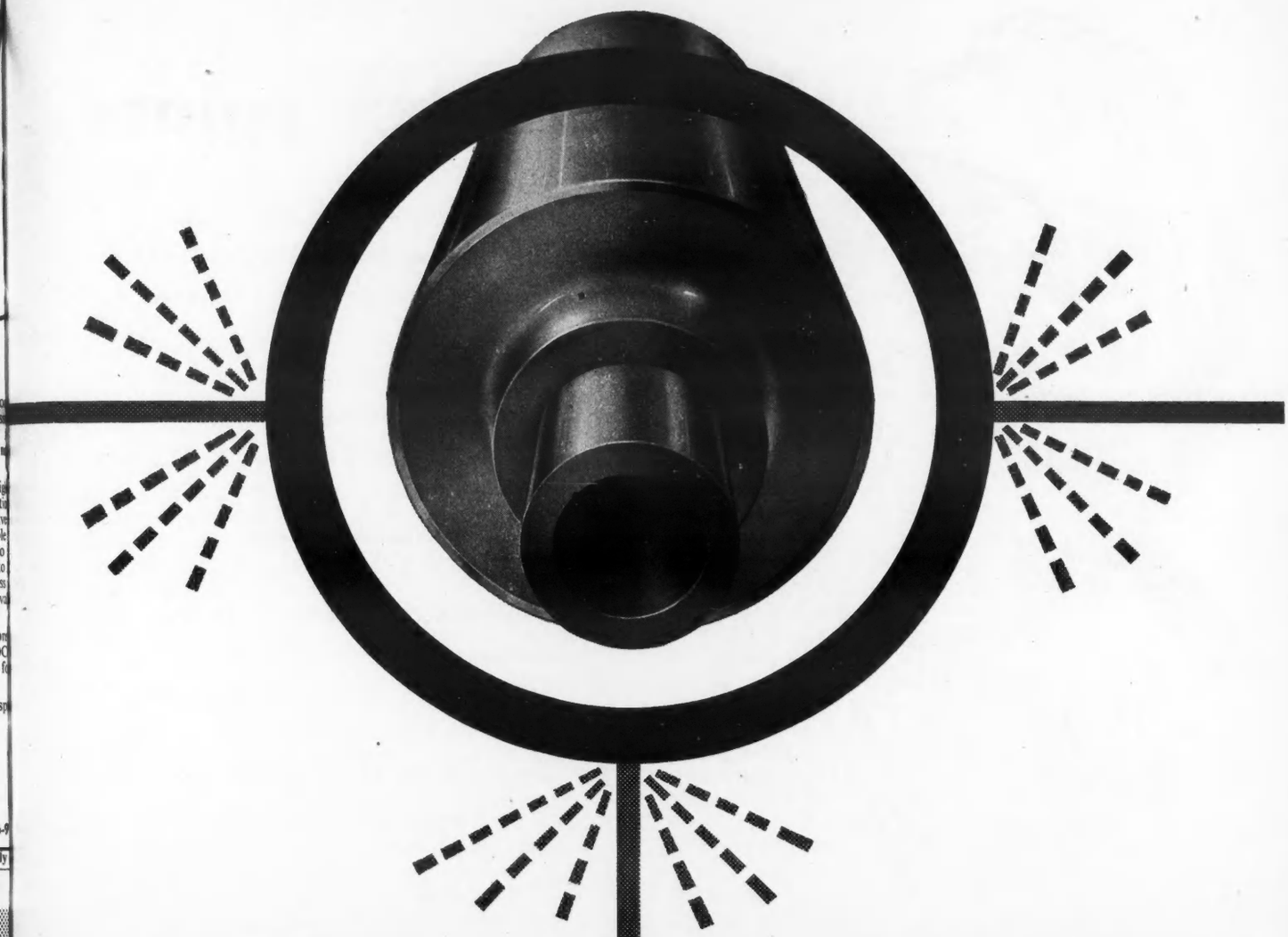

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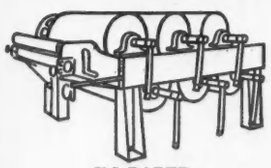

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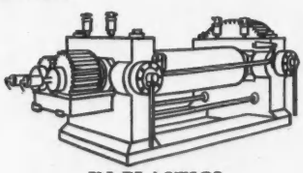

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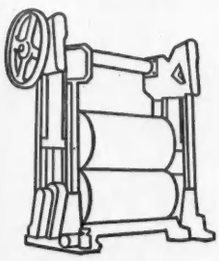

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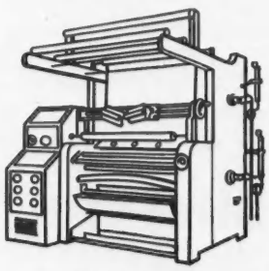

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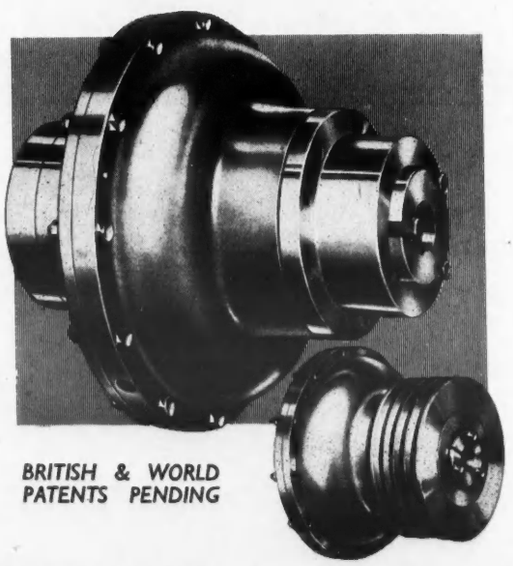

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THE ENGINEER

No. 5443 MAY 20, 1960 Vol. 209

AN END FOR AN HONOURED NAME

Within a few days the firm which has printed this journal from its very beginning will go out of existence. It was on January 4, 1856, that the very first issue of THE ENGINEER was printed. It was printed in the works of Samuel Taylor in Greystoke Place, off Fetter Lane, in the City of London ; and in the composing room of that firm there worked a man named George Reveirs, who had composed the original prospectus heralding the advent of the new journal. It is reasonable enough to assume that he composed much of its first issue. A few months later he became manager of the firm and in 1874 he bought the business from Samuel Taylor's executors. Under his name the firm of George Reveirs, Ltd., came into being in 1874 ; but as that change of name signified neither change of personnel nor of machinery and plant, it can be fairly claimed that this journal has been printed by the same firm ever since its inception.

It will be printed by George Reveirs, Ltd., no longer. To our deep distress, there has come not merely a parting of the ways, but an end to George Reveirs, Ltd. Some ten years ago that firm became a member of the Eden Fisher group of companies. One cannot be certain, but we do wonder whether any such thing would have happened had not tragedies during, and soon after, the first world war deprived the proprietors, descendants of the founder, of any heir or of any hope of one, to carry on the name. Now, in accordance with the development of the ideas of Eden Fisher that a weekly journal such as this can be as well, and at least as quickly, printed " in the country " as in London, and at an economy of cost, we have agreed that THE ENGINEER shall henceforth be printed at a new printing works which has just come into operation at Southend. Sadly enough, therefore, this is the last issue of THE ENGINEER to be printed by George Reveirs, Ltd. Very much more sadly it is almost the last thing which will be printed by that firm ; for Reveirs is to go out of existence and the printing works is to close. A few—distressingly few—of those who have worked for THE ENGINEER at Reveirs have opted to follow it to Southend.

Whilst we are excited by the change, excited by our power, which we believe to exist, to prove, with the help of certain recent technical advances, that a weekly newspaper can be printed with real advantage elsewhere than in London, we feel at this moment much more like weeping than shouting. Ordinary good-byes are hard enough to bear. But one can at least hope to hear from erstwhile friends and one can wish them good luck and splendid fortune in the future. We can hope and wish no such thing for Reveirs. This is a last and final good-bye. What we have written is an obituary.

SATELLITIC SPYING

The Summit Conference should have opened last Monday in Paris. As we go to press it seems obvious that it has been torpedoed by Mr. Krushchev because of the attitude of the Americans to the shooting down of an American reconnaissance aircraft deep within Russian territory. At first, the allies of the U.S.A., not believing that the event could have such serious consequences, gained a little (malicious) amusement out of an uncomfortable situation, through observing the acute embarrassment of the Americans. For, even when allowance is made for the natural determination across the Atlantic that no nation ever again shall do a Pearl Harbour upon them, it does seem astonishingly tactless that a reconnaissance flight right across Russian territory should have been permitted only a few days before the Summit meeting opened.

But in the minds of engineers different reflections were aroused. It occurred to us, for example, that engineering developments are setting some very awkward questions for diplomatists. There used to be a convention that no country ever gave recognition to its own spies. But in the instance under discussion the Americans clearly felt it quite impossible to pretend that the pilot of a very expensive high-flying aircraft full of valuable equipment was not flying under instructions from some American organisation. In fact, they not only " recognised " the pilot ; they said, openly, that if the Russians were determined to maintain secrecy about things happening within their borders then they, the Americans, must and would continue to make reconnaissance flights to ensure their own safety from surprise attack. Only at the last moment, and in the hope of saving the conference, did they say that such flights would be temporarily suspended. They also threw out the suggestion that soon earth satellites may be used to keep a photographic watch on Russian territory. Nor can there be any doubt of the practicability of operating such a satellite to take the desired photographs and to transmit them to earth ; the Russians themselves have demonstrated it by their success in photographing the back of the Moon. A satellite pursuing a more or less polar orbit at a relatively low level similar to that of the new object just put into orbit by the Russians, about which we comment below, would permit the whole of Russian territory to be regularly surveyed ; though photographs taken from 150 to 200 miles up would presumably reveal less detail than those taken from much lower levels. What would the Russians do then ? Would they shoot the object down just as they shot down the reconnaissance craft ? That would be to lay claim to sovereignty over space above Russian territory. How far out into space can a nation reasonably claim sovereignty ? It looks rather as though there may soon need to be agreement upon a space law akin to that which defines territorial waters at sea !

But, in truth, are not engineers making nonsense of the fears which lead to the secrecies of the Russians and the reconnaissances of the Americans ? For wealth and power in the world are no longer to be acquired by knocking out one's neighbour and stealing his goods or his territory. Instead, they are to be got by the industrial development of one's own country and by aiding the development of less advanced countries. That point is

as well-recognised by the Russians as by the Americans. In that context war has become a useless and wasteful exercise and full-scale nuclear war one destructive of the prosperity of all nations, that of the originator of the conflict just as much as the others. If it eventually helps some of those who attended this abortive Summit meeting into a better realisation that in the kind of world engineers and technologists are creating, war finds no rational place, the shooting down of a reconnaissance aircraft over Russia may come, at the end, to have done some good. Meanwhile, we suppose, the " cold war " has become warmer. Does it not all seem a bit childish and irrational ?

FOUR AND A HALF TONS IN ORBIT

Once again the Russians have demonstrated that they lead the world in the design of rockets for space research. As the Summit conference was due to open in Paris it was announced that a " space-ship satellite " had been placed in orbit and that it weighs no less than 4½ tons (metric). Remarkably enough this weight is reported to be exclusive of that of the final burnt-out rocket stage. Primarily the object is designed to test the practicability of launching a living man into orbit in such a satellite ; and within a cabin weighing about 2½ tons there has been placed a dummy man. Apparently no attempt is to be made to recover this cabin ; but under the command of a radio signal from earth it will separate from the rest of the object, plunge into the earth's atmosphere, and burn up. Something of the order of 1½ tons of instruments are carried. The placing of this new satellite in orbit obviously marks a stage in the development to manned flight. The practicability of launching an object of sufficient size has been demonstrated, and the instruments, it can be assumed, will indicate whether conditions within the cabin are tolerable to a man. Presumably the Russians are working also upon the problem of bringing a cabin back to earth undamaged. But the present object is to show only that the cabin can be successfully released from the satellite in such a way as to descend. The orbit of the new satellite is almost circular. It is about 226 miles above the earth's surface at its highest point and 188 miles up at its lowest. Since the orbit is almost polar, like that of earlier " sputniks," the Russians have demonstrated that they are as capable of satellite spying as the Americans if not indeed very much more so, though there is no suggestion that the new " space-ship satellite " is equipped with cameras for ground photography.

KARIBA

The " wind of change " on the African continent is neither entirely political nor necessarily destructive in its effects. What more progressive and beneficial symbol for the future of that vast continent could be called to mind than the great dam built at Kariba on the Zambesi, which Her Majesty the Queen Mother inaugurated at the ceremony last Tuesday ? An " engineer's-eye " view of the scheme, explaining the main outlines of its conception, was published in this journal last week, but some further comment is, perhaps, not out of place because the scheme illustrates how broad are the implications of such a vast development. The power generated, for instance, which is the *raison d'etre* of the scheme, will not be fully absorbed for eleven years, and the transmission system is designed on the basis that—with some reservation—there is virtually one source of power only. The dam will, however, regulate floods downstream, and the creation of the enormous reservoir may affect the climate beneficially.

Kariba is on the scale of the Zambesi itself, and the full river flow will be harnessed. The same applies at Owen Falls, in Uganda, but there the total capacity is only a tenth of Kariba's. Other hydro-electric schemes on the African continent include extensive exploitation by the French of the rivers draining to the Mediterranean, and the present Aswan hydro-electric scheme which is large, though not to the full scale of the Nile. Kariba is therefore the prototype of the really big schemes which the continent offers on a generous scale on rivers such as the Zambesi, the Nile, the Congo and the Volta.

When the Owen Falls scheme was completed a few years ago, it was described as an " act of faith " because it had been built in a region where the demand for electrical energy was negligible ; the scheme itself acted as a stimulus, and demand for energy has grown in a most encouraging way. Faith breeds on itself, in a sort of chain reaction, and clearly a similar but larger stimulus is expected to result from completion of the Kariba scheme, for the maximum load at present is a trifle, as compared with the potentialities of Kariba, and equally as at Owen Falls, it is envisaged that demand will grow rapidly. Electricity, let us freely remember, has its limitations. One cannot eat it, or worship it. It is merely the servant of a broader, more prosperous existence. Cheap power in the Rhodesias will not solve all the problems there, but will be of inestimable benefit in accelerating economic progress and making an immediate and important practical step forward.

ADVANCED STUDIES IN ELECTRIC TRACTION

In October the Department of Electrical Engineering at the Imperial College of Science and Technology will begin a ten-month post-graduate course in electric traction for men with honours degrees in electrical engineering, or the equivalent. This step is allied with the establishment in the department of a centre for advanced study and research in this subject, undertaken with the support of the British Transport Commission and the British Electrical and Allied Manufacturers' Association. From the prospectus of lectures it is clear that the course will provide organised instruction in the many specialised aspects of electric traction with which at present entrants to the industry with a general electrical engineering training must become familiar by the slower processes of experience and private study. Neither of these processes is wholly reliable, for some of those who have spent a career in traction and are genuinely anxious to pass on their knowledge are finding it hard enough to keep themselves abreast with developments, while the literature on the subject remains sparse and even the latest works are being rapidly overtaken by events. There have been some notable papers on new industrial-frequency traction techniques, but to learn in detail how they are being applied it is often necessary to have recourse to laborious researches in the Patent Office. Official descriptions of new equipment available in this country so far have a habit of raising as many questions in the inquiring reader's mind as they answer.

Students are already being enrolled for the course, and additional teaching staff recruited. The lectures will cover railway signalling and communications as well as traction fundamentals, economics and equipment, and will include twenty on rectifiers and inverters, both arc and semiconductor. Extensive laboratory work will be carried out, and it is stated that the academic group assembled for these purposes will, after appointment of a Reader, engage in a research programme in conjunction with the railways and industry. The Head of the

Department, Professor A. Tustin, has for some years been a member of the Research Advisory Council to the British Transport Commission. Some of the subjects under consideration for this programme suggest a future for electric traction which will give it new claims on the attention and interest of students and so assist in the recruitment of trained men now urgently needed. Indeed, the previous quiescence of traction in the academic field is reflected in the fact that it has been necessary to advertise for a Reader abroad as well as in Britain in order to tap adequate reserves of qualified men who might be released for the post. One of the subjects proposed is to explore new possibilities in combinations of rectifiers and machines arising out of the development of controlled semiconductor rectifiers of large power-handling capacity. The suggestion of further basic research into some complex commutation phenomena will be heard sympathetically by manufacturers of motors for electric and diesel-electric motive power who have encountered unforeseen problems and expense in this direction in recent years. It is also encouraging to read that the department proposes to be active not only in teaching but in promulgating knowledge. By publication of reports on its projects and results it could help in the process of drawing world attention to British enterprise in traction which the British Transport Commission hopes will be a by-product of the modernisation plan.

EFFLUENT AND WATER TREATMENT EXHIBITION

In October of the present year there will be held at the Seymour Hall in London an exhibition and convention for whose success we can sincerely hope. It is to be entitled the " First Effluent and Water Treatment Exhibition and Convention," and is believed to be the first venture of its kind to be held in Europe. Amongst the subjects to be discussed are the biological treatment of industrial wastes, river pollution in Scotland, pumping plant and problems, the application of polarography to sewage analysis, the disposal of radioactive wastes, and the softening of water. It will be observed that some of these subjects—in particular that of coastal pollution—are actively controversial and about others there is some degree of disagreement. There should, therefore, be interesting and constructive discussions since the exhibition and convention ought to bring together under one roof representatives of firms with effluent problems, of local authorities and of manufacturers of treatment plant.

But we miss something in the programme which does seem to us rather essential. Mr. Wakefield, chairman of the Coastal Anti-pollution League, will no doubt preach the need to keep the sea cleaner, and may perhaps make reference to the disgusting state of many of this country's estuaries. But there seems to be no one to present the case for clean rivers. People presenting papers appear to be those interested as research workers or engineers in purification processes or as industrialists in finding the means to comply with the law. None seems to have any very direct interest in making our rivers cleaner. There are several months to go before the exhibition and convention open. May we suggest to the organisers that they approach one of the more active River Boards to secure a paper which would indicate the present state of the law and its application, reveal the deplorable state of several of the rivers of this country, and point out how pollution is doubly harmful, first by destroying amenity, and secondly by destroying a local and cheap source of water supply ? It might go still further and point out that though any firm polluting a stream or river thereby secures for itself a cheap method of disposal of a waste product, it does so anti-socially at the expense of firms and domestic users downstream whose water supplies are made more expensive, and possibly also to the detriment of people living far away, from whose river water has to be abstracted.

REPORT ON CLEAN AIR

There really is not very much to write about the *Clean Air Year Book* just published by the National Society for Clean Air. It contains, as one would expect, particulars about the state of the law and especially of the Clean Air Act. It summarises the Beaver Report upon whose recommendations the Act was based, provides a synopsis of the " case " for clean air for the guidance of speakers and writers, and gives a peptonised history of air pollution in this country going back to 1273, when the use of coal was prohibited in London as being " prejudicial to health." The thirtieth annual report of the Society is printed between these covers. Some sentences from the report deserve, we think, more publicity than they are likely to get solely by publication in the *Year Book*, and we therefore reproduce them here. " While fully recognising the difficulties of the coalmining industry and the solid fuel trade, regret must be expressed at the efforts being made by advertising and other activities to restore the deservedly waning popularity of the raw coal open fire . . . . This reactionary attitude, we are glad to note, is not shared by all sections of the trade. . . . It should be emphasised the drive for clean air is not a drive against coal, but simply for its use in newer, cleaner and more efficient ways." Hear ! Hear !

The Engineer—100 Years Ago (MAY 18, 1860)

" THE EMBANKMENT OF THE THAMES "

" Has it ever been settled whether the Thames is really a river ? It is true that, at Gravesend, it is wider than the Danube at Galatz, the Nile at Rosetta, or the Mississippi at New Orleans. Yet, at Teddington Lock, there is not always enough water coming over for a respectable shower-bath. As a tidal pool Father Thames may have claims upon our veneration, but as a fluvial fact the metropolitan river is a small affair indeed. The Thames, up which the tidal wave of the German Ocean travels at a ten-knot rate, is certainly influential in purifying the metropolitan atmosphere ; excepting when only, from excess of sewage, it is equally influential in vitiating, if not in poisoning it . . . . It is not necessary, however, for all the good the river may do us, that its width at Hungerford be greater than that at London Bridge. If a breadth of 300 yards be enough to accommodate the commerce of the port of London, 300 yards ought also to be ample for all purposes of metropolitan ventilation, so far as an unrestricted tidal flow can affect it. Parallel with that axis of the capital upon which its heaviest traffic is compressed, the banks of the Thames furnish as much available space for new thoroughfares as would be equal to the Strand, Oxford-street, and the New Road combined in one . . .

" There is now a prospect that the Thames will be nearly roofed over with bridges. Within three years Chelsea Bridge has been thrown open and Westminster Bridge rebuilt, and now a great railway bridge is approaching completion at Pimlico, whilst two others, those of the Charing-cross and the London, Chatham and Dover lines, are about to be thrown over the river at Hungerford and at Blackfriars. Surely, if this encroachment may be permitted, a different and not less useful kind ought to obtain equal encouragement. It is to be hoped, for the best interests of the metropolis, that the committee appointed to consider the embankment of the Thames will report practicable and acceptable means by which this great improvement may be speedily secured."

Measuring Pitch Errors of Screws to High Accuracy*

By L. W. NICKOLS, B.Sc. (Eng.), M.I.Mech.E., M.I.Prod.E.

A new method of pitch measurement has been developed at the Laboratory to enable the pitch errors of screws having a vee-thread form to be measured to a considerably higher accuracy than formerly. The method employs an auto-collimator technique to compare the pitch of the screw with end-standards of length. The apparatus described has been designed to measure the pitch errors of precision leadscrews used in some types of measuring machines, within certain limitations of size, and is also suitable for measuring the pitch errors of the reference screw plug standards used to calibrate the pitch measuring machines employed in checking screw gauges. The accuracy of measurement attainable by the new method is dependent mainly on the accuracy to which the sizes of the end-standards are known, and the effect of any fluctuations in temperature from the standard temperature (20 deg. Cent.) which may occur whilst the pitch measurements are being made. Experimental results have indicated that, provided no temperature variations occur, the pitch may be measured in terms of the measured sizes of the end-standards to an accuracy better than ±5 microinches (±0·13μm).

(1) Introduction

THE pitch of a screw is measured by comparing the spacing of consecutive turns of the thread with a suitable standard of length, which is usually a line standard viewed by a microscope or the micrometer screw of a pitch measuring machine. The ever-increasing need in the engineering industry for improved accuracy of dimensional measurement applies in particular to the measurement of pitch errors of the precision leadscrews used in some types of measuring machines and the screw gauges used for inspecting workpieces. To meet this need a new method of pitch measurement has been developed at the National Physical Laboratory, which employs an auto-collimator technique to compare the pitch of the screw with end-standards of length. Apparatus was designed to measure the pitch errors of vee-threaded precision leadscrews, within certain limitations of size, and is also suitable for measuring the pitch errors of the reference screw plug standards used to calibrate the pitch measuring machines by means of which the pitch errors of screw gauges are usually determined. The pitch errors of these reference screw plug standards are required to be known to a very high degree of accuracy.

The accuracy of pitch measurement attainable by the new method is dependent mainly on the inevitable errors of determination of the sizes of the end-standards used, and the effect of any fluctuations in temperature from the standard temperature (20 deg. Cent.) which may occur whilst the pitch measurements are being made. Experimental results have indicated that, provided no temperature variations occur, the pitch may be measured in terms of the measured sizes of the end-standards to an accuracy better than ±5 microinches (±0·13μm).

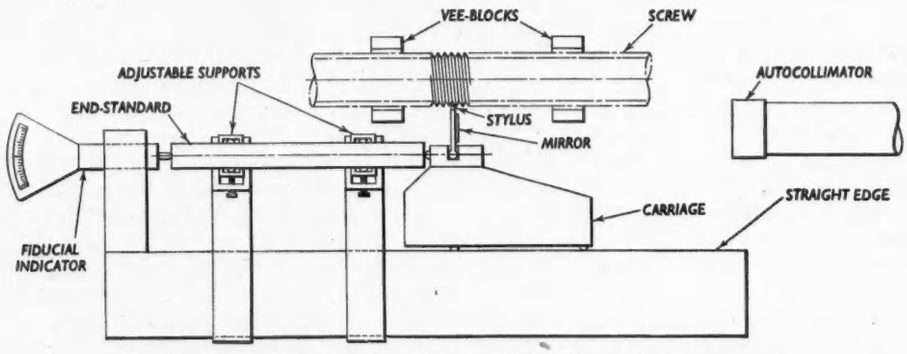


Fig. 1—Diagrammatic plan view showing principle of method of measurement

(2) Method of Measurement

The screw to be measured is mounted in vee-blocks on a surface plate so that the axis of the screw is parallel to the surface plate and to a straight-edge clamped on the surface plate. (See Fig. 1). A carriage is mounted on the surface plate against the straight-edge so that it may be moved in a direction parallel to the axis of the screw. A vertical mirror is kinematically mounted on the carriage in such a way that it may rotate about a vertical axis, and its angular position in a horizontal plane is determined by a stylus, attached to the mirror, which seats in the thread groove to be measured. The carriage is set in turn to predetermined positions along the straight-edge, corresponding to successive turns of thread, by the use of end-standards of length. Each end-standard is mounted on adjustable supports so that it may be lined up parallel to the axis of the screw; one end of the standard contacts a measuring head, used as a fiducial indicator, and the other end locates the carriage. A biassing mechanism (not shown in Fig. 1) may be used to ensure that the standard is brought into contact with the carriage. The change in the angular inclination of the mirror when the carriage is moved from the appropriate setting for one thread groove to that of another thread groove is measured by an auto-collimator, and serves to indicate the pitch error between the two thread grooves.

The carriage is designed to minimise the effect of errors of the surface plate and straight-edge, and it features a block magnet which clamps the carriage to the surface plate and straight-edge simultaneously.

(3) Description of Apparatus

Mirror and Support (Fig. 2).—The frame of the circular mirror has two $\frac{3}{16}$in (5mm) diameter balls mounted on one side at the positions shown, with the upper ball vertically above the lower ball. A ball-ended stylus is attached to the other side of the mirror. When the mirror is mounted in the apparatus the ball on this stylus contacts the flanks of the thread groove being measured on a pitch line of the screw which is at an angle of 45 deg. to the horizontal plane containing the axis of the screw. The lower $\frac{3}{16}$in diameter ball on the mirror seats in a built-up corner on the carriage formed by one horizontal and two vertical flat-lapped faces which are mutually square to one another, and the upper ball contacts the vertical lapped face *A*. When the mirror is mounted in the above way, its centre of gravity is well behind the plane containing the centres of the three balls, and the weight of the mirror causes the lower ball to be forced against the vertical face *B* and the horizontal face *C*, the upper ball to be forced against the vertical face *A*, and the stylus ball to move down the thread groove until the lower ball is in contact with the vertical face *D*. The mirror is thus located kinematically, and may be removed and replaced with the knowledge that it will take up its former position. When the mirror is mounted in the apparatus, any relative displacement of the carriage with respect to the screw in a direction parallel to the axis of the screw will cause the mirror to rotate about a vertical axis passing through the centres of the upper and lower balls. On the mirror used, the distance between this vertical axis and the centre of the stylus ball was 1in (25mm); consequently, a relative displacement amounting to about 5 microinches (0·13μm) causes the mirror to rotate through 1 second of arc.

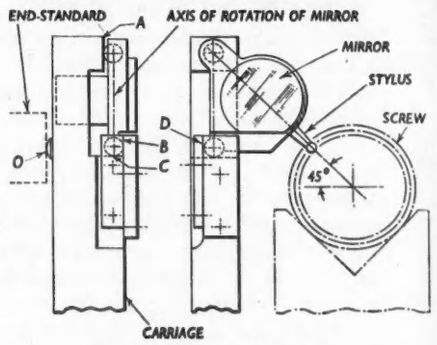


Fig. 2—Mirror and support

Carriage (Fig. 3).—The horizontal base *E* of the carriage rests on three feet, *F*, *G* and *H* respectively, on the surface plate; the bottom surfaces of these feet are lapped flat to be in the same horizontal plane. The foot *F* is magnetically insulated from the base *E* by an interposed brass spacer *J*. The base contacts the straight-edge through the ball *K* and the pad *L*. This pad does not touch the surface plate, and is magnetically insulated from the base by the brass spacer *M*. A block magnet of proprietary design is mounted on the base so that one pole rests on the foot *F* and the other pole rests on the pad *L* and the magnet is clamped in position by the two non-magnetic set-screws shown. When the plunger in the magnet is depressed the magnetic flux passes through foot *F* into the surface plate, and then back through the straight-edge into

* Communication from the National Physical Laboratory.

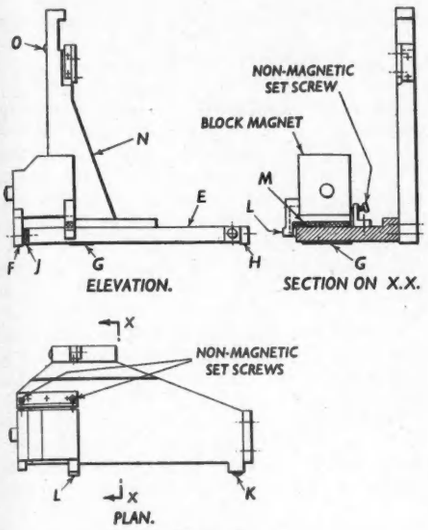


Fig. 3—Carriage

pad *L*; the effect is to clamp the carriage to the surface plate and straight-edge simultaneously.

On one side of the base is mounted a vertical plate *N*, the bottom of which forms foot *G*, and which has the mirror support at its upper end. A spherical ended anvil *O* is fixed to this vertical plate so that a line passing through its centre and that of the lower ball on the mirror is parallel to the straight-edge and to the surface plate. The end-standards against which the pitch of the screw is compared are in contact with the anvil *O* when the pitch measurements are being made.

End-Standard Supports (Fig. 4).—The end-standards of lengths above about 5in (125mm)

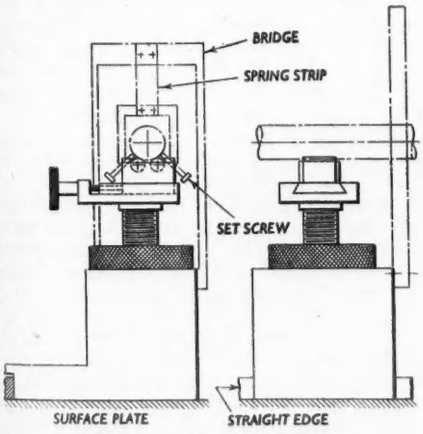


Fig. 4—End-standard support

are supported at their Airy positions on two adjustable supports. Each support consists of two balls which are free to move in a direction parallel to the axis of measurement within the confines of a built-up box having a flat lapped base and sides; this box is mounted on a base and is adjustable for height, and may be moved transversely to the axis of measurement in the manner shown.

It is not possible to use both adjustable supports for end-standards of lengths below about 5in because the widths of the bases of the supports prevent this. The solution adopted was to use one of the supports described above in conjunction with a second support which consists of a vee-frame suspended by a spring-steel strip from a bridge attached to the first support. This second support is indicated by the chain-dotted lines in Fig. 4. The position of the end-standard in the vee-frame may be adjusted by means of the two setscrews shown.

End-Standards.—The end-standards used were composite length bars, having the new screwed connections developed at the Laboratory,[1] in conjunction with slip gauges wrung to the end faces of the bars. The change in size at each connection when a composite bar of this type is assembled, caused by the stresses set up in the connection, is about 1 microinch (0·025μm) and is independent of the torque used when assembling the bars by hand.

Biassing Mechanism.—When measuring the pitch of long screws, correspondingly long end-standards have to be used, and the measuring force of the fiducial indicator may be insufficient to keep the end-standards in contact with the ball *O* on the carriage. In this case a biassing mechanism is used, as shown in Fig. 5. It consists of a spring-

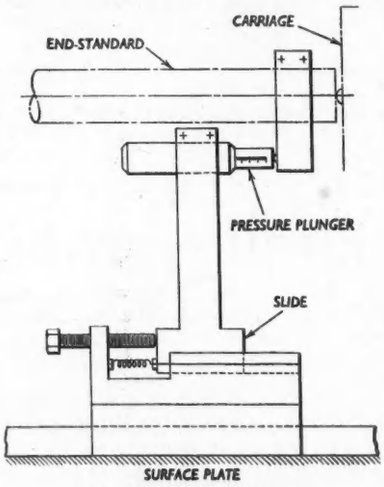


Fig. 5—Biasing mechanism

loaded "pressure" plunger which contacts a ball on a collar attached to the length standard near the end adjacent to the carriage, thus ensuring that the biassing force applied by the plunger acts only over a short length of the standard, and so has a negligible shortening effect on the length of the latter. The pressure plunger is mounted on a slide which has a screw-operated traversing movement to enable the biassing force to be adjusted to the desired value.

Fiducial Indicator.—A Mercer "Abramson" type Precimeter measuring head, having a magnification of 3000 and a scale divided into 0·00001in (0·25μm) divisions, was used as a fiducial indicator. This measuring head could be read to one-fifth of a division, i.e. 2 microinches.

Auto - Collimator.—A Hilger and Watts "Microptic" auto-collimator of the visual type was used. The micrometer of this instrument can be read to an accuracy of about 0·1 second of arc, which is equivalent to a stylus displacement of 0·5 microinch (0·01μm) in the direction of pitch measurement.

(4) Measuring Procedure

The screw is mounted on the vee-blocks with its axis parallel to the straight-edge and surface plate and in such a position that, with the carriage and mirror in place, the axis of rotation of the mirror is vertical and the mirror stylus contacts a pitch line of the screw at 45 deg. to the horizontal plane containing the axis of the screw (see Fig. 2). End-standards of appropriate length are then placed on their supports, and the positions of the carriage and fiducial indicator are adjusted until readings are obtained on the fiducial indicator and auto-collimator towards the middle of their respective ranges when the stylus engages the first thread to be measured. The end-standards are then aligned by means of the adjustable supports until a minimum reading is obtained on the fiducial indicator. The latter is then adjusted until it again reads at the mid-position of the scale, and is then clamped permanently in position. After allowing time for the temperature of the end-standards to return to normal after handling, the position of the carriage is again adjusted to bring the fiducial indicator back to the mid-position of the scale. Ten successive readings of the auto-collimator are then taken and the mean calculated, thus eliminating observer's errors so far as is practicable.

When making a fine adjustment to the carriage it is convenient to lock the latter in position by the magnetic clamp and then obtain the required position by tapping the carriage with a rubber mallet. The magnetic clamp prevents accidental movement of the carriage, but has the advantage that it permits fine adjustment in the above manner, for little difficulty is found in setting to the nearest 0·2 division on the fiducial indicator, i.e. to the nearest 2 microinches (0·05μm).

The end-standards are then increased by an amount equal to the nominal pitch of the screw over the interval to be measured, and the position of the carriage is adjusted to bring the fiducial indicator reading back to the mid-position of the scale. After placing the mirror in position, aligning the end-standards and allowing time for their temperature to return to normal, the carriage is adjusted to bring the fiducial indicator reading back to the mid-position again, and the auto-collimator readings are taken.

The pitch error of the screw over the interval measured is equivalent to the change in angular inclination of the mirror after taking into account the known errors of the end-standards.

Freedom from temperature fluctuations is vital when making measurements to a very high precision, and every precaution should be taken to ensure uniformity of tempera-

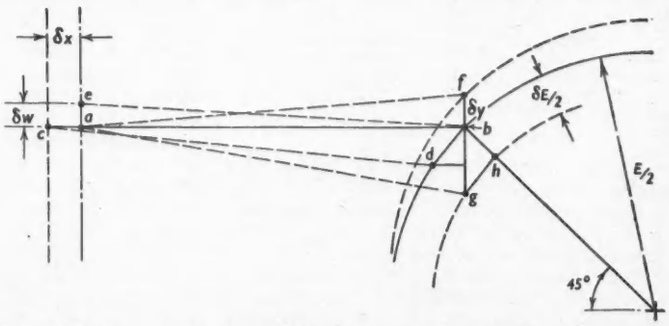


Fig. 6—Movement of mirror stylus along thread helix caused by various types of geometrical errors

ture. The measurements should be made in a temperature-controlled room and the apparatus housed in a draught-proof enclosure.

(5) Effect of Errors on Accuracy of Pitch Measurement

Geometrical Errors.—These errors may be of the following kinds:

(i) Errors of straightness of the straight-edge.
(ii) Errors of flatness of the surface plate.
(iii) Errors of parallelism of the axis of the screw to the straight-edge and the surface plate.
(iv) Variations in the effective diameter of the screw.

In accordance with the Abbé principle of alignment, the centre-lines of the anvil *O* (Fig. 2) on the carriage and the lower ball on the mirror lie on the extended axis of the length bar standard. The effects of errors (i) and (ii) above in the direction of measurement are thus reduced to a minimum.

In Fig. 6, *ab* represents the initial position of the radius of rotation of the mirror stylus when the latter is seated in the first thread of the screw ; this radius is measured from the vertical axis of rotation of the mirror to the effective diameter cylinder (diameter *E*) of the screw. When the carriage and mirror are moved along the screw from thread to thread the occurrence of the types of errors given above will cause *ab* to be displaced, relative to its initial position, in a plane normal to the axis of the screw. This displacement results in the mirror stylus moving up or down the helix of the screw as the pitches of successive threads are measured ; the pitch measurements are no longer made in the same axial plane of the screw and they will be in error. The ways in which *ab* may be displaced, and the resulting movement of the mirror stylus along the helix of the screw, are examined below. It is assumed that all the displacements are relatively small, the effect of any departures from verticality of the axis of rotation being negligible.

A horizontal displacement δx of the axis of rotation will cause *ab* to move to *cd*, the stylus moving along the thread helix by $bd=\sqrt{2}.\delta x$.

A vertical displacement δw of the carriage with respect to the screw will cause *ab* to move to *eb*, the stylus moving along the helix by a negligible amount.

A vertical displacement δy of the mirror stylus with respect to the carriage, caused by a change in the vertical position of the axis of the screw, will cause *ab* to move to *af*, the stylus moving along the helix by a negligible amount.

A change δE in the effective diameter of the screw will cause *ab* to move to *ag*, the stylus moving along the helix by $hg=bh=0{\cdot}5\delta E$.

The movements of the stylus along the screw helix caused by the above displacements are tabulated below :

Displacement	Movement of stylus along helix
δx (horizontal)	$\sqrt{2}.\delta x$
δw (vertical)	Negligible
δy (vertical)	Negligible
δE	$0{\cdot}5\delta E$

A movement of 0·0001in (2·5μm) of the stylus along the helix is equivalent to an apparent pitch error of $(0{\cdot}0001p/\pi E)$, where *E* is the effective diameter and *p* is the nominal pitch of the screw. In the case of a ¾in (19mm), 14 t.p.i. reference screw standard of Whitworth form this apparent pitch error amounts to 3·5 microinches (0·1μm).

It should be noted that, in practice, providing a high-grade straight-edge and surface plate are used, and precautions are taken to set up the apparatus as accurately as possible, it is unlikely that the above geometrical errors will result in the stylus moving along the helix by more than 0·0001in in the case of screws shorter than 6in (150mm). If the very highest precision of pitch measurement is desired, then corrections may be applied to compensate for these geometrical errors.

Error of Location of Mirror on Carriage and Screw.—It will have been noted from Section 4 that the mirror has to be removed from the carriage, after a pitch measurement has been made, before the carriage can be moved along the straight-edge to enable the pitch of another turn of thread to be measured. The accuracy with which the mirror can be remounted on the carriage is therefore of prime importance to the functioning of the apparatus ; this accuracy of location was examined in the following way.

The position of the carriage along the straight-edge was adjusted until, with the mirror mounted on the carriage and screw, the reflected image of the auto-collimator crosswires was in the field of view of the auto-collimator ; the carriage was then locked in position. Ten successive readings were then taken on the auto-collimator and the mean reading calculated. The mirror was then removed from the carriage and screw, replaced in position again, another ten readings taken and the mean reading calculated. This latter procedure was then repeated twice more. The maximum spread in each of the four sets of readings was 0·3 second of arc. The spread of the four mean readings was 0·11 second of arc, equivalent to a stylus movement of 0·5 microinch, with respect to the vertical axis of rotation of the mirror, along the generator of the effective diameter cylinder. This proved that the mirror could be located in position on the carriage and screw to an accuracy equivalent to that to which the micrometer of the auto-collimator could be read.

The author desires to acknowledge the assistance given by Mr. D. A. Varcoe in the experimental work carried out to prove the design of the apparatus.

The work described above has been carried out as part of the Research Programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

REFERENCE

[1] Nickols, L. W., "Influence of Screwed Joints upon the Overall Length of a Combination of Length Bar Standards," *Machine Shop Magazine*, 1956, 17, 550 ; *Machinery*, 1956, 89, 473 ; *Metalworking Production*, 1956, 100, 1649.

Eighth International Automobile Technical Congress

No. I

The Eighth International Automobile Technical Congress of the Fédération Internationale des Société d'Ingenieurs des Techniques de l'Automobile (F.I.S.I.T.A.) was held at The Hague from May 9 to 13. Papers presented at the congress covered a wide field and the first part of the following report confines itself to the more significant points of those papers which dealt with the future of the motor-car and with fuel and combustion problems.

Automobile of the Future

THE series of twenty-nine papers submitted to the Eighth International Automobile Technical Congress held last week at The Hague by the Fédération Internationale des Société d'Ingenieurs des Techniques de l'Automobile (F.I.S.I.T.A.) included two which dealt at some length with the future of the motor-car.

Professor J. J. Broeze, of Delft University, dealt with "The Automobile of the Near Future," and confined himself, in the main, to the next five years. Within this period he foresaw little change. In particular, he said, there would be no major change in the two classes of vehicles which formed the bulk of passenger cars in Europe : the "minicar," defined as a four-wheeled vehicle providing reasonably comfortable transportation at the lowest economical level, and the executive or professional car providing a greater degree of space and comfort, and at present powered by engines of about 2 litre swept volume. In the former category it was logical to expect increased use of air-cooled engines, but the author came out strongly against the continued use of two-stroke engines ; other developments singled out as pointers to the future were the compact engine/transmission assembly of the B.M.C. small cars, the automatic transmission of the D.A.F. and the air spring of the Renault "Dauphine." In general, progress with automatic transmission was expected to be slow in Europe, but traffic conditions called for a reduction of the demands made on the driver, who should be able to concentrate on steering, speed control and signalling. At present the two problems which demanded most urgent attention in the "minicar" category were the development of a corrosion proof exhaust system and improvement in the heating and ventilating.

In contrast, "The Automobile of the Distant Future," by Dr. A. A. Kueher, Vice-President—Engineering and Research, Ford Motor Company, U.S.A., foresaw several changes. The growth of population and *per capita* income is expected to increase the car population of Western Europe to 33,000,000 in 1965, compared with about 16,500,000 in 1959, and the annual rate of production is expected to rise from the present level of around 4,000,000 cars, trucks and tractors to 6,000,000 in 1965, and 8,000,000 in 1975. As the automobile market develops, there will be a need for a wide variety of vehicles, not all wheeled. Among those vehicles there will be highway cruisers, urban commuting minicars and miniature coaches for city and suburban travel. The expected increase in the volume of traffic will also demand a new approach to the problem of mass transportation. One example of this, in the field of high-speed medium distance travel, is the Ford Motor Company's "Levacar," a wheelless vehicle operating on tracks at speeds of 200 to 500 m.p.h., which is said to provide an economical means of moving passengers at distances of 100 to about 1000 miles.

In general, according to the author, the major changes will lie in the three fields of energy and its conversion, of materials and of controls. Of the three, the field of energy promises the farthest-reaching

changes : future fuels will have a higher density of energy than gasoline and in systems other than the familiar automobile engine fuel will be converted directly into electrical energy. The most promising of the devices by which the conversion may be achieved is the fuel cell ; it represents a major step in the direction of electrically-powered cars, but at present its bulk is excessive. Moreover, in the present stage of development, the hydrogen-oxygen type of cell is also uneconomical because of the high cost of fuel, while the more economical propane-oxygen cell suffers from diffusion and cell contamination by carbon. The high-temperature cell, operating at 500 deg.–850 deg. Cent., uses low-cost fossil fuel, but its life span is short, and the need for a ceramic matrix to retain an electrolyte of molten salt also raises problems.

A related question is that of high efficiency electric motors whose development should be well advanced within the next twenty years. Another development showing considerable promise is a hybrid vehicle combining a small piston engine and electrical storage devices. The engine would operate continuously at high efficiency, charging a battery which would provide energy for small electric motors to drive the wheels.

In spite of progress with other kinds of power units, the reciprocating spark-ignition engine was expected to continue to be widely used in cars. One of its challengers, the gas turbine, will be used initially for inter-urban passenger transport and freight hauling, while the free-piston turbo-compound engine was considered particularly suited to tractors and earth moving equipment.

In the field of materials plastics offer perhaps the widest field for speculation. If current research directed at increasing their strength is successful, plastics may replace many of the outer surfaces of cars, with saving in weight and freedom from corrosion. Otherwise adhesives are expected to replace welding as a method of fabrication and assembly.

As operating speeds and traffic density increase, there will be a need for electronic anticipatory controls to assist the driver, whose response time would no longer be adequate. In particular, there will be proximity indicating devices which would show distances and closing rates, and warn the driver of impending danger.

Fuel Developments

In the first group of specialist papers on power units, transmissions, fuels and lubricants two very similar papers discussed the development of fuels and their contribution to improved car performance. One of the two was by J. A. Beukers, of Esso Nederland N.V., and K. Arter, of Esso Research, Ltd., who, under the title "Progress in Motor Fuels," examined three particular aspects of gasoline quality in which there have been significant developments, namely, anti-knock qualities, volatility, engine deposits.

So far as anti-knock quality is concerned, motor fuels are graded according to their research octane number, and this has been rising steadily. The trend is shown clearly in Figs. 1 and 2, which apply to premium and regular grade fuels in the four principal manufacturing countries of Europe. Both grades normally contain some tetra-ethyl lead, which is still the cheapest way of raising octane number, but lead contents in Europe continue to be lower than in the U.S.A., and the improvements noted in Figs. 1 and 2 have been made possible by new manufacturing techniques. The catalytic reforming process, using a platinum

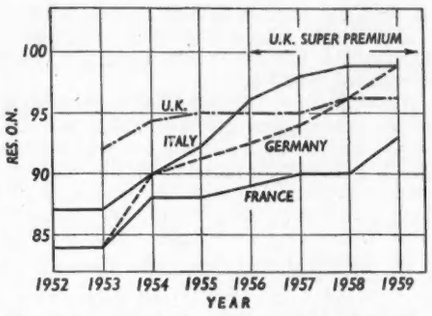


Fig. 1—Increases in the octane number of premium grade petrol

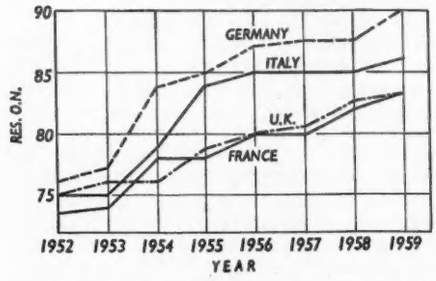


Fig. 2—Increases in the octane number of regular grade petrol

catalyst, is currently favoured for raising the base octane number.

For quality control purposes the use of the A.S.T.M.-C.F.R. single-cylinder engine is universally accepted, but the relation between the octane numbers determined in this laboratory unit and the anti-knock behaviour of the fuels in vehicles on the road continues to be the subject of much study. Hydrocarbon/air mixtures differ in their anti-knock performance according to the type of engine and its operating conditions, so that a given fuel can have significantly different road octane ratings when tested in a number of different cars.

Masterman and co-workers,* have developed a generalised road octane equation of the following (simplified) form :

Road octane number

$$=b_1R_T+b_2R_a+b_3M_T+C \quad . \quad . \quad (1)$$

where

R_T and M_T = Research and motor octane numbers respectively

R_a = Research octane number of some front-end fraction representing $100a$ per cent distilled from the gasoline b_1, b_2, b_3 and C are constants.

The term $b_2 R_a$ is needed because motor gasoline is a mixture of many different hydrocarbon fractions which distil (under atmospheric pressure) between about 40 deg. and 180 deg. Cent. Individual fractions may differ considerably in octane number and the laboratory octane number of the whole gasoline is effectively a weighted average of all the component fractions.

It is well known that when the throttle of a multi-cylinder engine is opened suddenly for acceleration from a low speed, conditions in the intake manifold become unstable ; some of the heavier fuel fractions condense on the wall of the manifold and several seconds may elapse before these reach the cylinders. If the highest anti-knock quality is concentrated in these heavy fractions the fuel reaching the cylinders during acceleration must be lower in octane number than the whole gasoline present in the float bowl. This phenomenon is termed fuel segregation and its effect on road octane number depend on the octane number distribution over the boiling range of the gasoline and the design of the engine intake manifold. The constants b_1, b_2, and b_3 will vary according to the latter, typical values being illustrated by the following equation :

Road octane number

$$=0{\cdot}45R_T+0{\cdot}32R_{0{\cdot}75}+0{\cdot}19M_T+C \quad . \quad (2)$$

When engine speed is sensibly constant there will be no fuel segregation in the manifold and the equation simplifies to :

Road octane number

$$=m_1R_T+m_2M_T+C \quad . \quad . \quad . \quad (3)$$

typical values quoted by Masterman *loc. cit.* for a 1958 European car with a four-cylinder o.h.v. engine being :

Road speed, m.p.h.	m_1	m_2	C
30	0·5	0·3	+24
40	0·5	0·6	−9
50	0·1	1·0	−3

Most European cars exhibit maximum knock below 30 m.p.h. and to-day the research octane number is the most significant factor in anti-knock quality. There could, however, be a future shift in emphasis caused, for example, by a general adoption of automatic transmissions whereby full throttle engine speeds of less than, say, 2000 r.p.m. would be impossible.

The utilisation of anti-knock quality depends both on engine design and adjustment. With regard to the latter, it is a matter of common experience that apparently identical cars differ widely in octane requirements. One cause of this is variation in the ignition timing, due to incorrect static setting, wear in the distributor or manufacturing variations. An octane requirement survey of 160 cars, covering thirty-nine models, made last year, showed that only sixty-six had correct static ignition setting within ±1 deg., whilst fifty—i.e. nearly one car in every three—were over advanced by amounts ranging from 1·5 to 20 deg. Subsequent tests showed that the change in research octane number per degree error in spark timing ranged from 0·5 to 1·5 for all but five of the fifty over-advanced cars.

Modern refining methods favour the production of gasoline with high front-end volatility. The motorist gains from this in winter because his engine warms up quickly, and the designer benefits too because he needs less heat on the intake manifold, and

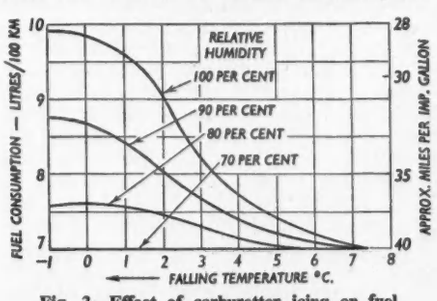


Fig. 3—Effect of carburetter icing on fuel consumption

so gets more power. On the other hand, it is necessary to take suitable precautions against vapour lock in the summer, and there is a risk of carburetter icing under certain humid conditions in the winter.

Ice formations in the choke tube are liable to occur at between 40 deg. and 30 deg. Fah. when the humidity is 80 per cent or more. The driver becomes aware of the trouble through loss of power, or even stalling of the

* Masterman, D. M. A., Potter, E. B. V., Skull, A., and Sprake, C. H., "Road Octane Number of Past, Present and Future Gasolines," Fifth World Petroleum Congress, New York, May, 1959.

engine. The phenomenon is well known, but it is not always appreciated that it may cause a substantial increase in fuel consumption as shown in Fig. 3, which refers to a small car having a critical type of carburetter. It was found that fuel consumption could increase by 20 per cent before loss of power became noticeable to the driver. Another form of carburetter icing is more usual in large American engines, in which ice forms around the edge of the throttle plate at, or near, idling position.

Both forms of icing can be avoided by the use of suitable additives, which depress the freezing point of any water droplets in the fuel-air mixture or prevent the agglomeration of ice particles. There is, however, an economic limit to what can be done in this direction and the provision of optional warm air to the carburetter is a recent trend which, in the opinion of the authors, deserves to be encouraged.

Combustion chamber deposits are always unwelcome because they increase octane requirements and may impair the efficiency of combustion. The tendency of hydrocarbons to form such deposits goes up sharply with increasing boiling point. It follows that deposits may be minimised by suitable processing to avoid the inclusion of high boiling materials, particularly aromatics, However, it is impossible to avoid some deposit formation. Starting with a clean engine, the octane requirement rises quickly at first, but it usually levels off after 4000 to 5000 miles. An equilibrium stage is then reached, when old deposits burn off as fast as new material is formed, but the equilibrium weight of deposit appears to decrease with compression ratio.

The second of the two papers on fuels, on " Recent Developments in Automotive Fuels and Lubricants," by F. A. Wadsworth and R. Q. E. Eden, of Shell International Petroleum Company, Ltd., stressed that not only did the octane number of the fuels sold in Europe increase considerably during the past five years, but the relative offtake of the premium grades increased considerably. In fact, of the total increase in motor gasoline used in Europe in 1959 as compared with 1955, no less than 78 per cent are accounted for by the premium grades.

In addition to developments in anti-knock quality, considerable attention has been devoted to combustion chamber deposits. As compression ratios increase, engines become more sensitive to them and the most important development in this field is the growing use of phosphorus additives for the control of surface ignition and spark plug fouling. In the U.S.A. this kind of additive is now regarded essential with high compression engines. Rumble or pounding, the multiple surface ignition phenomenon, has not yet become a problem in Europe, but milder forms of surface ignition, such as " wild ping," are not uncommon and, in some heavily congested cities, spark plug fouling is definitely troublesome. Tests in cars driven under such city traffic conditions show that not only does phosphorus prevent plug fouling, which occurs within 1200 to 3000 miles when no phosphorus is used in the fuel, but it will clean fouled plugs again within a further 300 to 1400 miles.

Motor oils also play a significant part in the formation of combustion chamber deposits. In particular, the metallic deposits left in the combustion chamber from the lubricating oil additives are becoming increasingly detrimental in causing power loss and abnormal combustion. The rumble or pounding experienced in American engines provide an illustration of this. However, modern car engines cannot operate without additive type oils and progressively higher standards of lubricant performance are being demanded in new designs.

Consequently, the lubricant requirements of the new engines are becoming contradictory. Higher performance oils are needed which would conventionally be met by increasing concentrations of metallic additives. However, these would at the same time contribute to combustion irregularities which threaten to be a brake on progress in specific output. The new approach is to use entirely non-metallic oil additives to solve the twin problem of metallic ash deposits in the combustion chamber and wasteful depletion.

The relatively slow depletion of the non-metallic additives, coupled with their excellent low-temperature dispersancy, result in outstanding engine cleanliness. However, radioactive tracer wear tests on used oils show that the factors controlling oil drain intervals are still contamination and fuel dilution, and that it is unwise to try to extend oil life because of improved additive life. The reduced weight of combustion chamber deposits is considerably greater than can be accounted for by omission of the lubricating oil metallic ash, and this must have some binding or synergistic effect.

The elimination of metallic ash from lubricating oil and the incorporation of a suitable phosphorus additive in the oil have a beneficial effect which reinforces that obtained with the phosphorus-treated fuel. Thus, spark plug fouling is further reduced by lubricating oils with entirely non-metallic formulations. Equally, the use of such formulations containing phosphorus is beneficial in suppressing rumble or pounding and, in tests using a critical engine, improvements in pounding at limited power, of about 40 to 50 per cent were obtained in changing from conventional additive oils to the non-metallic formulation. The associated problem of piston burning is similarly favourably influenced.

A very interesting summary of work on " combustion problems in gasoline engines " was presented by F. W. Bowditch, of the Research Laboratories, General Motors Corporation. The work was carried out with two single-cylinder engines, an A.S.T.M.-C.F.R. knock-test engine in which a 6·75 : 1 compression ratio, quartz window and " L "-head were substituted for the standard engine parts, and a special quartz piston overhead valve engine. The latter is shown schematically in Fig. 4 and embodies a quartz crown on the piston with a stationary canted mirror within the piston which permits the reflection of the combustion process to be seen in the mirror when the engine is running. In both cases an Eastman high-speed camera, Model II, with an f.1·9 25mm focal length lens was used to take high-speed motion pictures of the combustion processes. The field of view of the camera for the overhead valve engine is shown in Fig. 5.

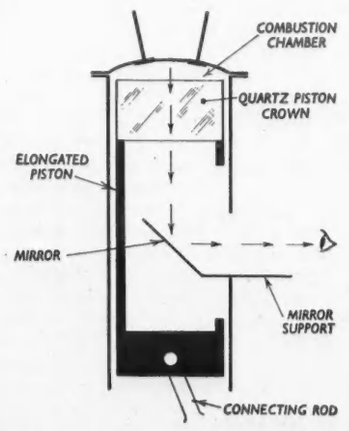


Fig. 4—Schematic view of quartz piston engine

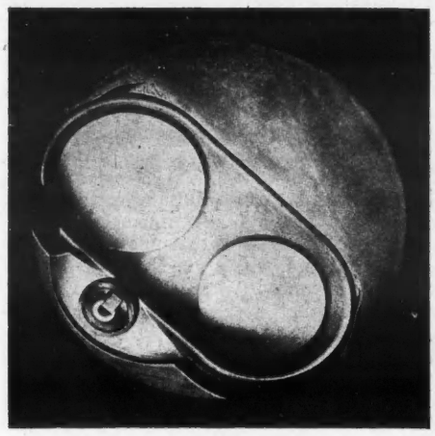


Fig. 5—High-speed camera view of quartz piston engine

The combustion processes studied and described concerned undesirable types of explosions classified according to the mode of ignition into those where ignition occurs in the gas phase and others where ignition occurs at the surface. The first category included spark knock, after running and hot starting. The last is a problem of sufficient magnitude in the United States that the size of starter motors on most American cars is determined by the torque requirements for starting under hot, rather than cold, engine conditions. There is evidence that initiation of explosions which give rise to difficulties in starting hot is due to compression ignition (sometimes called " dieseling "). After running is also due to compression ignition and both may be alleviated by increasing the anti-knock quality of the fuel. The degree required makes this impractical, however, in most cases. Alternative solutions consist of enriching the fuel-air mixture temporarily by pumping the accelerator pedal or, in the latter case, completely shutting off the air supplied to the engine.

Surface ignition explosions discussed included those initiated by deposits and hot spots. Deposit ignition explosions are, among others, responsible for the engine noise known as rumble, believed to be caused by the high rate of pressure rise and high peak cylinder pressure. This inflicts a shock load on the engine power train which in turn causes it to vibrate at its natural frequencies—hence the rumble noise. In practice, deposit ignition problems may be eliminated by deposit composition control. An accumulation of carbon as engine deposits will not normally cause deposit ignition in an engine. However, if lead salts as well as carbon make up the deposits, the deposit ignition is likely to occur because the lead salts lower the ignition temperature of the carbon. An exception are lead phosphate salts and the addition of various phosphorus compounds to the fuel, which leads to the formation of phosphorus salts of lead with higher ignition temperatures than the salts they replace, reduces or eliminates deposit ignition.

(*To be continued*)

Dimensional Aspects of Lost Wax Investment Casting*

By R. TAYLOR AND N. MASON

This paper deals with the dimensional aspects of lost wax investment casting which is often claimed to be accurate to ±0·005in per inch but regularly fails to achieve this tolerance. The paper discusses the several factors which result in the "scatter" of "as-cast" dimensions in lost wax castings and presents diagrams of actual production check data illustrating the general level of reproducibility of "as-cast" dimensions achieved by the conventional lost wax process. The paper outlines the collation of production check data to form the basis of a more accurate and reliable formula for predicting master pattern and die contraction allowances. The value of the "precision," or reproducibility which can be achieved "as-cast" in terms of practical economics and engineering, is also discussed.

PRACTICALLY every component undertaken for manufacture as a legitimate lost wax casting forms both a challenge and a compromise. The challenge consists in the endeavour to meet certain tolerance ranges "as-cast" and by this means obviating machining, either expensive or otherwise. The compromise can take one or more forms, for example :

(1) Certain dimensions or areas intentionally cast with excess material to allow a finishing operation to bring the component inside limits narrower than those economically achieved "as-cast."

(2) Holes left solid, where a high level of accuracy and location of the centres is called for and where a finishing operation such as reaming would be difficult.

(3) Modifications of casting design to facilitate its manufacture as a casting or ease subsequent machining operations.

Obviously, the range of tolerance laid down by the customer's drawing and to which the investment founder endeavours to work, should never be tighter than is necessary for the correct functioning of the component. Unfortunately, however, a high percentage of component drawings submitted to the investment founder are what might be called "tool-room" drawings, where many, if not all, dimensions are shown to two or three decimal places and to tolerances of the order of ±0·003in or ±0·001in. Whilst these are normal and strictly applicable for production by conventional machining operations, turning, milling, &c., in many instances, some of these tolerances are not functionally necessary and the wider tolerances achieved by lost wax casting can, by agreement, be acceptable for the part in service.

Paradoxically, what is probably the investment founder's greatest problem is never encountered in the foundry itself. This is the difficulty of endeavouring to "sell" precision castings and, on being pressed for a definition quoting "generally ±0·005in per inch." When getting down to case details, it becomes necessary to modify this claim on so many counts, e.g. a fillet here, 0·030in grinding allowance there, some narrow, deep, recess cast solid, that it is not altogether surprising that buyers, engineers and designers, unfamiliar with the overall intrinsic value of the process, come to the conclusion that it will be cheaper to machine the component from the solid.

The basis of the value of the process is its ability to save on production costs, in both time and money, and particularly to achieve results which, either due to shape or material, are impractical by conventional machine-shop methods. There is no justification for the premise that it is a threat to the very existence of machining and allied techniques. The inability to appreciate this point often leads to difficulties in establishing realistic inspection standards based on the criterion "will the casting make to the final drawing ?" Considerable work has and is continuing to be done to alleviate this misunderstanding. Such organisations as the British Investment Casters' Technical Association, the American Investment Casting Institute, and the European Investment Casters' Association, are helping towards this end. Reward for these efforts must surely take the form of an intelligent, unbiased approach to the problems of the investment founder by the engineer designer, who will assist by accepting a compromise as well as offering a challenge. Ideally, every user of bought-out investment castings should have at least one member of its staff fully acquainted with all the pros and cons of the subject. Practically this is impossible and it is, therefore, up to the investment founder to provide the expert opinion and guidance.

[The paper then deals with the causes of dimensional variation, typical production variations and gives data designed to minimise one cause of production variation.]

Limit on Tolerance Achieved by Casting

In connection with dimensional tolerance ranges, detailed analysis has shown certain grounds for suggesting that on the smallest dimensions better than ±0·005in can often be obtained, thus where no adverse factors exist, the investment founder might reasonably offer to supply "as-cast" dimensions as follows :

0·000in to 0·25in ±0·003in.
0·25in to 0·50in ±0·004in.

The foregoing comments centre on the problems involved in achieving "as-cast" dimensions, i.e. the foundry aspects. However, every casting must have some area or areas where it must be separated from the ingates or feeder-head. The separation may take the form of cutting by friction saw, abrasive disc or cutting torch, and the cut area consequently requires cleaning up by grinding or linishing. Where these areas are non-critical, or where a machining allowance has been incorporated, only semi-skilled hand finishing is called for. Where, however, the tolerance required is of the order of ±0·005in, or even closer, and where the customer is unable to accommodate such finishing, the investment founder is obliged to extend its activities outside the scope of foundry practice and demands a different class of labour. In many cases, however, simple gap gauges may be used to aid in linishing the ingate area dimensions to the required limits. Naturally, this can also refer to areas other than the ingate areas, e.g. portions of the castings where the "as-cast" variation is not controllable to the limits called for. After final heat treatment, shot-blasting, &c., the casting then shows no evidence of this finishing operation and the resultant component is undistinguishable from an "undoctored" lost wax casting, and the resulting implication is that the process is far more accurate than in fact it is. It is well known that some investment foundries, e.g. those tied to aircraft firms, are integrated with engineering workshops and it is natural for them to approach production of components from the general standpoint of engineering as distinct from foundry products. For the designer and the buyer of investment castings as "bought out goods" from an investment foundry, the position is rather different. The foundry hopes to operate as a foundry without the added expense of a complete machine shop designed to produce components to tolerances which the casting process is incapable of meeting. The cost of such dressing operations to fine limits and machining practice adds considerably to the cost of the component and is usually completely out of balance to the actual cost of producing the casting.

Where a foundry undertakes such work it follows that in many cases it must be cheaper to have these engineering operations integrated with the customers' own machining operations, in which case the "two-step" procedure means that too high a price is paid for the so-called casting. Conversely, in other cases, it is a great convenience for the customer to receive components ready for immediate use, even if the foundry has had to finish them. It is not surprising, therefore, with the different practices employed by investment foundries, the buyer and designer at large are at a loss to establish what is to be expected as an investment casting.

It is hoped that the foregoing will have succeeded in clarifying the position of the investment founder who attempts to compromise between the price which puts the precision casting out of court and at the same time endeavours to give the customer what is asked for. Finally, however, it is hoped that present and potential users of investment castings will more readily appreciate the considerable mutual advantages to be gained from technical collaboration with the founder, from the design and inquiry stage.

* Paper presented at the annual meeting of the British Investment Casters' Technical Association, May 18.—Abstract.

Book of Reference

Sand and Gravel Handbook. The Sand and Gravel Association of Great Britain, 48, Park Street, London, W.1. Price 20s.—In his foreword, the chairman of the Sand and Gravel Association of Great Britain states : "This handbook answers the questions on sand and gravel with which engineers are daily confronted." The thoroughness of the compilations in the succeeding pages bears out this view. Amongst the topics dealt with there is, first, a comprehensive regional directory of the sources of sand and gravel aggregates which are exploited by the Association's member firms. The handbook then outlines relevant definitions and such like background technical matters, going into somewhat detailed explanations of the technicalities involved in the various major uses of sand and gravel aggregates, that is for concrete, "dry lean" types of concrete, building sands, roadstone, coated stone and filter media. Testing and screening plant are discussed, relevant British Standards and the Association's publications are both listed, and there is a note on the Association's research department.

Instruments, Electronics and Automation Exhibition

No. I

The third International Instruments, Electronics and Automation Exhibition will be opened at Olympia, London, on Monday, May 23, by Lord Mills, Paymaster-General and former Minister of Power. It will remain open until Saturday, May 28. With 150,000 square feet of stand space, this year's exhibition is stated to be twice the size of its predecessors. We begin below a review of some of the exhibits.

A TOTAL of some 500 exhibiting firms at this year's Instruments, Electronics and Automation Exhibition includes 100 from overseas. There have been increases in participation by Government departments and official bodies in addition to an influx of new exhibitors which reflects the expanding trend of the electronics and associated industries. The group of industries sponsoring the exhibition is represented by: The British Electrical and Allied Manufacturers' Association, the British Industrial Measuring and Control Apparatus Manufacturers' Association, the British Lamp-blown Scientific Glassware Manufacturers' Association, the Drawing Office Material Manufacturers' and Dealers' Association, the Electronic Engineering Association and the Scientific Instrument Manufacturers' Association of Great Britain.

From May 24 to 26, in the course of the exhibition, the Electronic Forum for Industry will hold its first full-scale conference for the presentation and discussion of papers covering practical experience in data processing, factory applications (including machine tool control) and instrumentation. These sessions will also be held at Olympia.

Among official bodies, the Department of Scientific and Industrial Research will illustrate by displays of twenty-five new instruments and measuring techniques from its laboratories and research associations, some important aspects of its work in encouraging the wider application of science in industry. Several of the instruments have already been taken up for manufacture, among them being a resistance spear thermometer developed at the Torry Research Laboratory originally for research on the processing, preservation and transport of fish (Fig. 1). This instrument has many other possible applications in situations where temperature must be measured rapidly in difficult conditions. Its operation is based on the variation of the resistance of a small copper coil contained within the tip of a hypodermic needle—the spear—which may be thrust into materials or liquids. Temperature is indicated on a calibrated dial attached to a variable resistance that forms part of a simple Wheatstone bridge, one arm of which contains the coil. Particular features are that the instrument is capable of measuring temperatures with an accuracy comparable with that of a good mercury-in-glass thermometer, it is simpler to use than a thermocouple and potentiometer, and is light and robust. In addition, the response of the element is roughly ten times as fast as that of a mercury thermometer and, since indication is remote from the spear containing the element, the instrument can be used in places where it would be impossible to use a normal thermometer.

Exhibits by associations within the D.S.I.R. will include a transistorised radio telemetering system developed by the British Internal Combustion Engine Research Association. The system, which uses small but robust encapsulated units, will be demonstrated on a sectioned working Petter AVA2 diesel engine. A transmitter complete with aerial is mounted inside a piston reciprocating in a cylinder, transmitting temperature indications. The piston, with a transducer mounted in its crown, comes in contact with a heating element at the top of the cylinder and a compressed air jet at the bottom of the cylinder (this arrangement producing a maximum contrast signal on the C.R.O.). The carrier frequency of 2 Mc/s (to suit proprietary equipment at the receiving end) is varied directly by the transducer signal, and at the receiving station the frequency variations are converted into voltage variations suitable for display on an oscilloscope.

The British Iron and Steel Research Association will show a method under development for measuring the speed of steel strip before and after rolling, without direct contact. Two photocells are aimed at two illuminated spots a fixed distance apart on the strip pass line. Small irregularities in the light reflected from the strip surface give rise to a certain pattern in the output of the first photocell. After an interval of time depending on the strip speed, a similar pattern appears in the second photocell. Thus, if the output of the first cell is delayed (e.g. on a tape recorder) and then added to the second photocell signal, a maximum combined output will be obtained when the delay time introduced is equal to the time for passage of a point on the strip surface between the two photocells. Knowing the delay time and the distance between the illuminated spots, the strip speed can be calculated.

An example of D.S.I.R. support for research projects by means of special grants will be shown in a " 3-D " microscope (Fig. 2) designed at the Cambridge University Physiological Laboratory. The microscope gives a three-dimensional image or luminous model of the object under examination. When a thick specimen is under observation by a

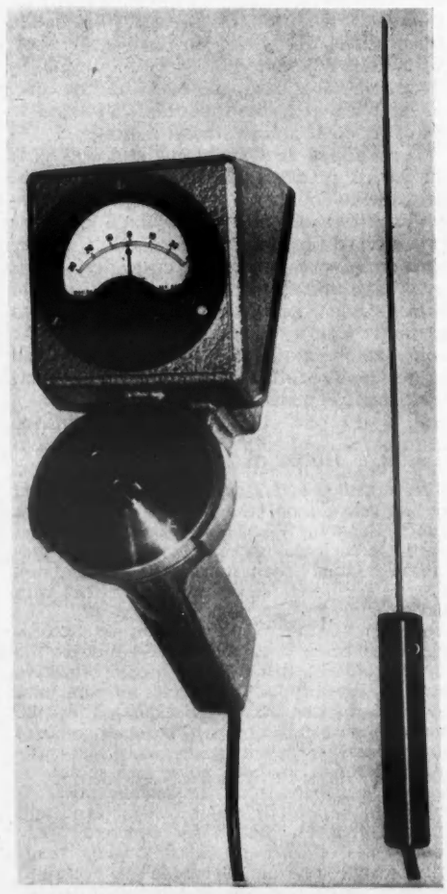


Fig. 1—Resistance spear thermometer. The " spear " (a hypodermic needle containing a sensing element in its tip) is on the right

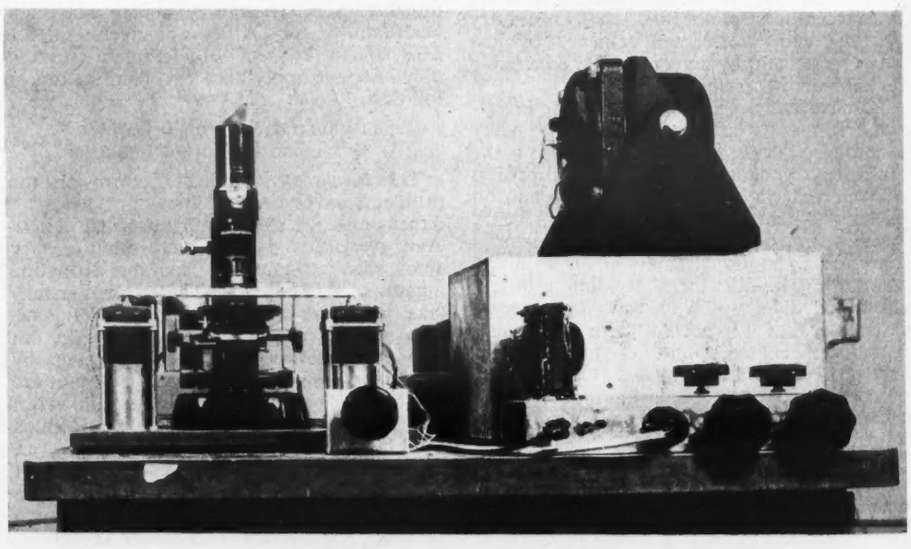


Fig. 2—Three-dimensional microscope showing prism through which image is projected on to the vibrating screen on right—D.S.I.R.

normal microscope, only a thin section of it can be in sharp focus for any one setting of the focusing screw and it is only possible to examine the complete specimen by focusing successively through the specimen. This limitation is actually put to use in the operation of the solid image microscope. The solid image is built up by vibrating the focusing mechanism up and down so that the thin plane of focus scans the object in depth. The constantly changing image given by the scan is then projected on to a screen which vibrates in precise synchrony with the object scan but with greater amplitude. The magnified image is formed in the cube of space swept by the vibrating screen. It is quite steady because the rate of scan is too high for the flicker to be seen. The microscope is intended particularly for biological research, but it is suggested that the solid image might be a useful way of displaying nuclear tracks in blocks of emulsion for cosmic ray research. Other applications which suggest themselves are to assist the assembly of very small electronic devices such as millimetric waveguides and transistors.

The close interdependence of the three subjects named in the title of the exhibition is demonstrated in the displays of exhibiting firms by the wide use of electronics in instrumentation, and the many forms of instrumentation from which the information necessary for automatic control systems is derived. We review below a selection of the exhibits which will be seen when the exhibition opens next week.

The English Electric Company, Ltd.

Four divisions will be represented on the stand of The English Electric Company, Ltd., Marconi House, Strand, London, W.C.2, namely data processing and control systems ; meters, relays and instruments ; ransformers ; and the instrument wing of guided weapons. The first of these is showing a multi-point scanning equipment incorporating new basic logical elements of "building block" style known as "Datapacs" for electronic data-logging and processing. The units are printed-circuit transistorised packages measuring 4½in by 6½in. Instrumentation displays will include a new range of traction instruments for measuring current, voltage and speed, some of them with 240 deg. or edgewise, edge-on illuminated, engraved "Perspex" scales. We illustrate (Fig. 3) a new exhibit from the Instrument Wing of English Electric Aviation's Guided Weapons Division, Stevenage. This is a direct-reading permeameter designed specifically as a quality control instrument for measuring the permeability of samples of magnetic material and small components such as gyroscope stators and rotors, and it can be read by unskilled operation without any calculation. In principle the instrument measures a.c. permeability at a frequency of 6 c/s as defined by the value

$$\frac{\text{Peak flux density } (B)}{\text{Peak intensity of magnetisation } (H)}.$$

The sample is held in a magnetising fixture designed so that insertion of a probe automatically completes two toroidal windings of ten turns each round the sample, one a primary or magnetising winding and the other a secondary winding. Arrangements are also made in the fixture to neutralise the induced secondary voltage due to leakage flux. The primary winding is excited from a 6 c/s a.c. supply provided by a built-in power amplifier. Permeability of the sample is indicated directly on a 6in meter.

For a.c. permeability measurements, the instrument may be calibrated using a master sample of any material, the characteristics of which have been determined by classical methods or by calculation. For d.c. permeability measurements, the instrument may be calibrated using a master sample of the material concerned. By incorporating a simple modification, it is possible to measure incremental permeability in the presence of a d.c. biasing flux. It is expected that this will be a standard feature of future production instruments.

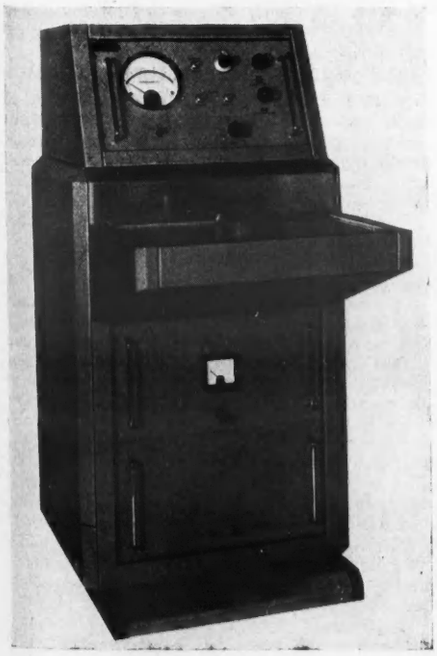


Fig. 3—Direct-reading permeameter for quality control of magnetic materials and small components—English Electric

English Electric Valve Company, Ltd.

Over 150 different varieties of electronic tubes will be shown on the stand of the English Electric Valve Company, Ltd., Chelmsford, including tubes for communications, radar, sound and television broadcasting, industrial heating and control, and data processing. We illustrate in Fig. 4 a new reflex klystron oscillator, K361, designed specifically for use in Doppler speed measuring systems where reliable performance with minimum routine attention are primary requirements. Typical applications of this low voltage reflex klystron include an equipment produced by the Westinghouse Brake and Signal Company, Ltd., for automatically controlling the speed of hump-shunted rolling stock in railway marshalling yards, and police radar Doppler speed measuring systems. Mechanical tuning of the klystron is effected, over the frequency range of 10,700 to 10,725 Mc/s, by a single-screw tuner intruding into the cavity. The K361 has a minimum output power of 20mW, and is fitted with a coupler for connecting to No. 16 waveguide (0·9in×0·4in internal dimensions). Overall dimensions of the oscillator are 2·875in by 1·825in by 1·500in. Resonator and reflector voltages are +300V and −200V respectively, and the resonator current 25mA.

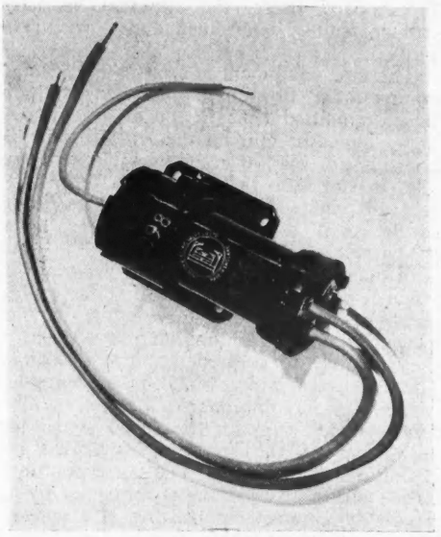


Fig. 4—Reflex klystron oscillator designed for use in Doppler speed-measuring systems—English Electric Valve Company

Ferranti, Ltd.

Exhibits on the stand of Ferranti, Ltd., Hollinwood, Lancs, will be provided by the instrument, computer, guided weapons and electronics departments, and the Scottish group of factories. A development to be seen in viscometers is the modification of the Ferranti-Shirley cone and plate instrument to incorporate a new automatic flow curve recorder.

With the cone and plate viscometer, the fluid to be examined is sheared in a narrow gap between a stationary flat plate and a slightly conical, rotating disc, driven at controlled speeds, ranging from 0·1 to 1000 r.p.m. by the variable-speed motor. The cone speed is directly proportional to the rate of shear. The amount of viscous drag on the cone is shown on an indicator unit and is directly proportional to the shearing stress. Thus, at any rate of shear

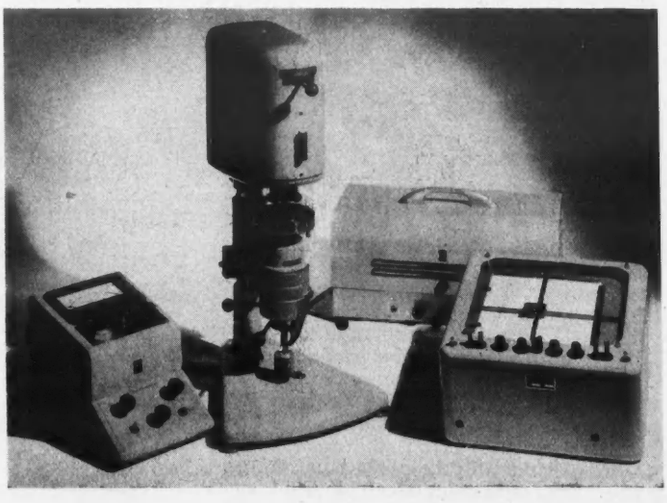


Fig. 5—Viscometer with automatic flow curve recorder—Ferranti

or shearing stress, the apparent viscosity can be readily determined and flow curves plotted.

The new equipment is seen in Fig. 5 and comprises a flow-curve recorder adaptor unit, seen fitted beneath the existing viscometer indicator unit on the left, so that all controls are readily accessible in one unit, and a Houston Instruments HR-92 X-Y recorder, right. Most types of X-Y recorder can be used, however, provided they have the correct input characteristics.

In operation, the control unit generates a voltage increasing linearly with time which is applied to the d.c. servomotor in the measuring unit via an amplifier, to accelerate the cone up to a predetermined velocity. The tacho-generator, which is an integral part of the servomechanism controlling the cone velocity, supplies the speed signal to the Y-axis of the recorder, calibrated in revolutions per minute. The corresponding torque acting on the cone is measured by a precise dynamometer consisting of a spring and potentiometer which supplies the torque signal to the X-axis, calibrated in dynes-centimetre. Multiplying by the appropriate cone constants gives the shear stress/shear rate characteristic in absolute units.

On reaching the maximum speed the cone normally reduces speed automatically to zero, but a " hold switch " has been incorporated to maintain the preset speed constant for any desired time before speed reduction is initiated. There are eight available rates of acceleration, the cone velocity being swept from zero to maximum speed (10,100 or 1000 r.p.m.) in a time ranging from ten to 600 seconds with a linearity of about 1 per cent. Intermediate maximum speeds can be selected by means of a ten-turn potentiometer. However, in applications where the duration of shear must be minimised, as when accelerating to a specific cone velocity before beginning the test proper, a rapid acceleration/speed reduction facility with a sweep time of about one second is available ; this is an overriding switch control, and, as such, it may be used to speed the setting up and resetting operations. The sweep voltages are generated by a conventional Miller integrator.

Ferranti, Ltd., will also be showing the " Sirius " and " Argus " transistorised digital computers, the co-ordinate inspection machine, electronic fault detector for 132kV grid lines, and many silicon semiconductor devices.

SERVOMEX CONTROLS, LTD.

On the stand of Servomex Controls, Ltd., Crowborough, Sussex, an electric resistance analogue field plotter, FP.92 (Fig. 6), will be shown which, in conjunction with special resistance paper, enables maps of potential and flow lines to be drawn by operators having no special skill. To use the instrument the operator considers his problem and converts his quantities to electric field terms. He then paints conducting electrodes in silver paint in any shape he likes on a plane of " Teledeltos " paper. The electrodes are connected to the FP.92, in which an internal power supply sets up a voltage between them, and also across the measuring potentiometer system. Ratio readings are set on a calibrated potentiometer. The ratio potentiometer tap connects with a probe through a galvanometer which indicates balance. By means of the probe the voltage at any point on the paper can be measured. The operator searches the field for balance, which he marks with the pencil point on the probe. In a few minutes he can plot sufficient equipotential lines to give a graphic and accurate solution to his problem. Results

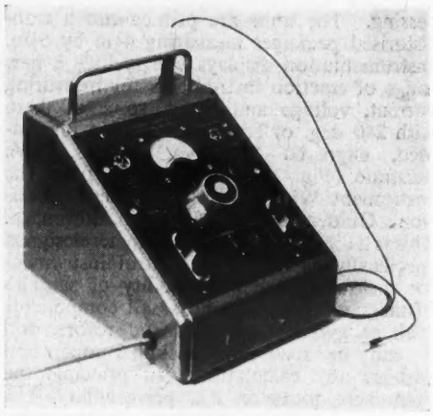


Fig. 6—Resistance analogue field plotter—Servomex Controls

are generally accurate to 5 per cent, and can be closer with special effort.

Among other Servomex exhibits will be an addition to the company's range of servo building units, i.e. electronic units which, together with a servo motor and mechanical connections form the basis of a number of automatic control systems. The new unit is a constant-current armature supply operating from a.c. mains and giving a constant direct armature current irrespective of back electromotive force within wide limits. Products of an associated company, Feedback, Ltd., will include an analogue and simulator unit for teaching the basic principles of simulators and analogue computers. The unit will be shown in operation providing facilities for instructional experiments on control systems of three general kinds : (1) Representation of a system by identifiable passive networks in conjunction with variable-gain isolating amplifiers ; (2) simulation of basic networks using amplifiers as integrators ; (3) real time and repetitive simulation of control systems in analogue computer form.

THE GENERAL ELECTRIC COMPANY, LTD.

We illustrate in Fig. 7 an altitude encoder system developed by G.E.C. for the Ministry of Aviation. The equipment will provide height information from an aircraft altimeter to a transponder in the form of a six-digit cyclic binary code over the range from 5000ft to 32,000ft. Two cyclic binary coded digitisers are fitted into a Mk. 22 modified altimeter manufactured by Smiths, Ltd. The digitised altimeter reading is taken by cable to the encoder which supplies height information to the aircraft transponder for transmission to the ground. As demonstrated, six lamps on the encoder will show the code transmitted. The numerical display gives the height, and the decoding is accomplished by means of a diode matrix that is typical of the type of circuit used in the ground station receiving equipment.

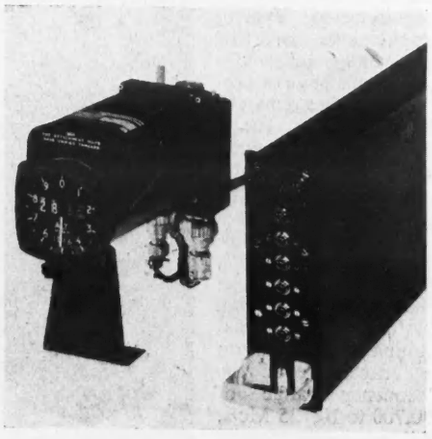


Fig. 7—Altitude encoding system for aircraft—G.E.C.

The company will also show a drive equipment providing, in a form suitable for use by factory labour, all the functions necessary for the running of a VEM 5·2 or similar vibrator. The vibrator is operated in the frequency range 30 c/s to 10 kc/s by a low distortion amplifier with a nominal output of 2·5kW. Acceleration level of the vibrator table may be controlled within close limits by a rapid-response g control unit operating on any one of three accelerometers, with independent level indication on a meter scaled logarithmically from $2g$ to $100g$. An external signal source or one of two internal sources may be used. The internal motor-driven sweep oscillator is controlled entirely from the front panel and may be swept between any preset limits in the 30 c/s to 10 kc/s range, at sweep speeds between four and 140 seconds per octave. A manual control may be used to set any required single frequency and the frequency, once set, may be held indefinitely. The internal tape recorder is a twin-track, automatically reversing machine providing a half-hour continuous playback, repeated indefinitely, with a reversing time of less than five seconds.

Also on the G.E.C. stand, Salford Electrical Instruments, Ltd., will exhibit a new series of multi-range test sets including a pocket-size unit, the " Minitest " with accuracies of ± 2 per cent full scale for d.c. amperes and volts and ± 3 per cent full-scale for a.c. volts. Exhibits by the G.E.C. Semiconductor Division will include a new 1in square stack assembly for medium-power silicon diodes, now extending in range up to 800V, together with a sub-assembly permitting stacking of these diodes for voltages up to 150kV and currents up to 2A.

The M.O. Valve Company, Ltd., will include in its exhibits a new v.h.f. triode for use in conditions of extreme vibration and shock, and a new double-triode designed for use in computers.

(*To be continued*)

Outer Space Temperature Research

BONN UNIVERSITY OBSERVATORY is shortly to begin an intensive investigation into the temperatures prevailing in interstellar gas. Special amplifying equipment employing travelling wave tubes has been manufactured to assist the University in this project by Marconi's Wireless Telegraph Company, Ltd., of Chelmsford. This equipment consists of a dual-channel amplifying system incorporating two travelling wave tubes in cascade in each channel.

The radio telescope, a parabolic mirror, 83ft in diameter mounted on a pyramidal tower about 60ft high, scans the sky picking up the cosmic continuum radiation emanating from galactic and extra-galactic radio sources under observation. The signals in the neighbourhood of the hydrogen line frequency (1420 Mc/s) are amplified by one pair of travelling wave tubes, the other pair being used to amplify reference noise signals from a resistor at a known temperature. The outputs from the two amplifying channels are detected, integrated and compared, and the effective cosmic temperature determined ; from these data contour maps are prepared. In initial tests with the system a discrimination of 0·1 deg. K has been achieved.

The research programme at Bonn University Observatory is being carried out under the direction of Professor Becker, who is assisted by Herr Heinz G. Müller. The travelling wave tubes used were manufactured by The English Electric Valve Company, Ltd., Chelmsford.

Copper Rod Rolling Mill

A continuous copper rod rolling mill just opened at the Prescot Works of British Insulated Callender's Cables, Ltd., is capable of rolling bars 4ft 6in long and weighing 265 lb down to ¼in diameter rod 1300ft long in ninety-five seconds. It produces rod from ¼in to ⅜in diameter in steps of 1/16in, and has an annual capacity of 100,000 tons of coiled rod. The installation includes two intermediate-finishing and finishing trains enabling the rolling of two different rod sizes at the same time.

TO meet the increasing demands for copper rod for the cablemaking and other activities of the British Insulated Callender's Cables, Ltd., group there has been opened at the Prescot Works, a fully automatic rod rolling mill which has an annual capacity of 100,000 tons. This new mill, which has cost some £1,500,000 to build and equip, is designed to produce rod from ¼in to ⅜in in steps of 1/16in. Its layout can be seen in the diagram and photographs we reproduce, and a noteworthy feature in its design is that following the initial roughing mill there are two separate intermediate finishing and finish rolling trains whereby two different sizes of rod can be rolled at the same time. The complete rolling installation for the mill was supplied by the Brightside Foundry and Engineering Company, Ltd., of Sheffield, to the special requirements of British Insulated Callender's Cables, Ltd.

The mill is housed in a 520ft long 104ft wide shop, outside one end of which there is a 40,000 square feet stockyard for the wirebars. These bars, each weighing some 265 lb, and averaging about 4in square by 54in long, are delivered into the shop in 43-ton batches on charge cars. From the cars the bars, in rows of seven, are unloaded by overhead travelling cranes and placed upon one of four sets of conveyors as shown in Fig. 2. These conveyors charge two re-heating walking beam furnaces, spaced 30ft apart, which were supplied by the Wellman Smith Owen Engineering Corporation, Ltd. The furnaces are oil-fired, and in the hour it takes a bar to pass through them it is heated to a temperature of 810–830 deg. Cent. Each furnace has two sets of beams, and the feed from the conveyors is timed to space the wirebars 3⅛in apart on the beams. The feed sequence of the bars into the furnaces and their movement is so timed that a heated bar is discharged from each one of the four sets of beams in turn and one bar is delivered every thirteen seconds out into the mill.

The heated bars fall on to rollers and are carried to a cruciform turntable between the furnaces and this table, rotating backwards and forwards through 90 deg., directs the bars into the mill train. A single roller-driven guide trough into which the bar is fed by an electro-pneumatic pusher takes the bar along to the first roughing mill. This 20in three-high roughing mill can be seen in the foreground on the left in Fig. 4. Five passes are made in this mill reducing the bar in steps to 12·427 square inches; 8·90 square inches; 5·63 square inches; 3·945 square inches, and finally 2·50 square inches cross section when the length is about 30ft. From the final pass the rod runs out on to a chain-driven, side-transfer table on which it is carried over for the start of the next rolling sequence.

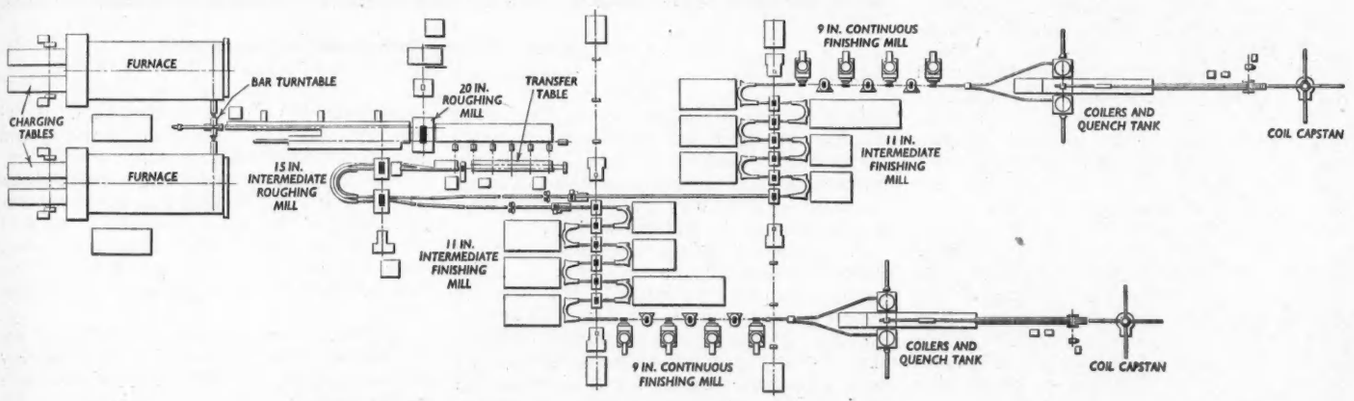


Fig. 1—Arrangement of plant in the automatic copper rod rolling mill at Prescot works

The rod is moved from the transfer table through a set of pinch rolls to the 15in two-high, two-stand intermediate roughing mill which is the start of the duplicate roughing, intermediate and finishing rolling trains. The incoming rods are directed alternately by an automatic switching device to the first stands of the two roughing mills in turn and in passing from the first to the second stands loop back on a semi-circular tray to be seen in the right foreground of Fig. 4. From the intermediate rolls the

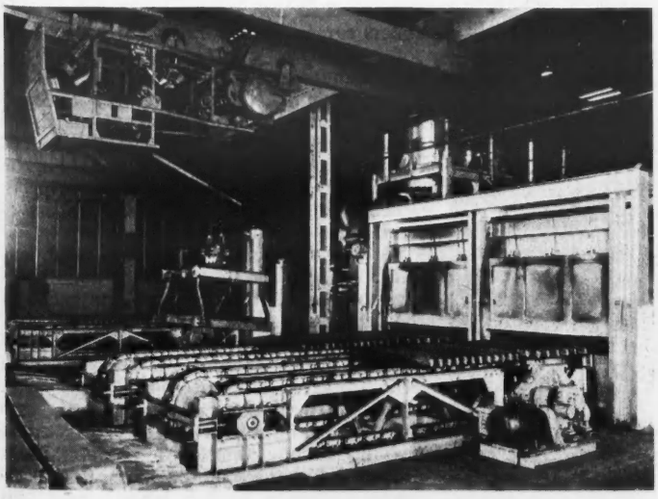


Fig. 2—Loading wirebars on to the feed conveyors of the twin re-heating furnace

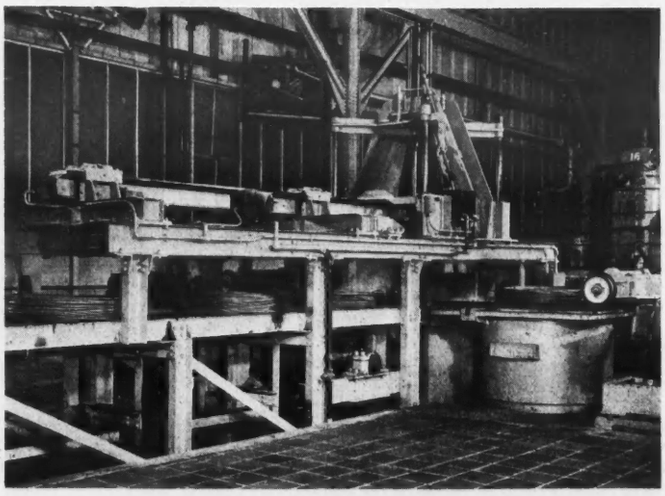


Fig. 3—Rod coiler, coil quenching gear and discharge conveyor

rods, now 64·7ft long, pass to one or other of the two sets of 11in intermediate finishing rolls. Each of these mills comprises six stands set in a line, and between each mill the rod is looped back in a tray to impart a zig-zag sequence in rolling. In its passage through the six intermediate stands the length of a rod is increased to 429ft in 8·2 seconds, and it passes straight from the final stand to the first stand of the continuous finishing mill at a speed of 30ft per second.

These 9in seven-stand finishing mills (Fig. 5) are fitted with cantilever suspended multi-grooved ring rolls, which are set alternately in horizontal and vertical planes to avoid twisting of the section at the high pass speed. All seven passes of the finishing mill are used to roll ¼in rod, and the roll centre variation to determine rod size is effected through a hand-operated worm gear by which an eccentric sleeve carrying one roll bearing is rotated. The copper rod leaves these finishing mills at a speed of 50ft per second, and the total time taken to produce a ¼in diameter 1300ft long rod from the original bar is only about ninety-five seconds. With the system of semi-continuous duplicated intermediate and finish rolling trains seven wire bars pass simultaneously through the mill about seven seconds out of phase.

All operations in the mill are controlled from push-button desks in three pulpits, one pulpit serving the initial rolling sections, and one pulpit serving each of the two intermediate and finishing mill trains. From these pulpits roll drive speeds can be adjusted, and at key points in the rolling sequence photo-electric cells actuate equipment controlling the movement and spacing of the rods as they pass through the plant. The need for a close degree of automatic control can be appreciated when, as previously mentioned, seven wire bars can be progressing through the mill at any one time.

From the finishing rolls the rod passes out into one of two coilers situated on each side of a central quenching tank in which the coils are cooled. These coilers (Fig. 3) are used alternately, and whilst one is in use the coil on the other is being pushed over into the quenching tank. A conveyor removes the coils from the tank and carries them to the loading station of a four-boom capstan. When nine coils have been placed on one of its booms the capstan is rotated through 90 deg. to present an empty boom at the loading point. The coils are removed from a loaded boom by a stacker truck on which they are transferred to a storage area at the end of the shop.

Fig. 5—One of the two continuous finishing mills and control pulpit

A soluble oil solution, which is used to flood lubricate all the roll grooves, roller guides, stripper equipment and transfer channels in the mill, is supplied by a central system. Four 600 g.p.m. pumps circulate the oil-water solution through the system, and it gravitates back to two large settling tanks. These settling tanks and an associated sump have a total capacity of 60,000 gallons, and the solution is prepared in a 1000-gallon mixing tank.

The warmed water from the coil boshes overflows into settling sumps in the mill floor and four pumps in each sump continually circulate the water at the rate of 15,400 gallons per hour. A forced draught cooler incorporated in the closed system of pipework reduces the temperature of the water from 146 deg. to 96 deg. Fah. A by-pass spillway and coke filter in the system remove the finer solids in suspension.

All the pushing and pulling mechanisms in the mill are operated electro-pneumatically, and air for this equipment is supplied through a ring main fed by two compressors, each capable of delivering 300 cubic feet per minute of free air at 80 lb per square inch.

All the motors used on the mill floor are of English Electric manufacture and they have a total rating of 6000 h.p., the maximum power requirement of the plant being 2·5MVA.

The roughing and intermediate roughing mills are each driven by a 6·2kV, 600 h.p. slip-ring induction motor, whilst the two intermediate finishing mills are split, each set of three stands being driven by a 500V, 500 h.p. d.c. variable speed motor. Each stand on the two continuous finishing mills has a 500V, 100 h.p. d.c. variable speed motor. The power for these motors, fourteen in all, is provided by two 1250kW grid-controlled mercury arc rectifiers which also supply the motors for the intermediate finishing mill. The four rod coilers are driven by variable speed 65 h.p. d.c. motors which receive their power from two motor generator sets, each of which is independently controlled so that the speed of each pair of coilers can be set accurately for each size of rod.

A maintenance bay in the mill, used for stand assembly, guide assembly and roll storage, includes facilities for storage and erection of the spare stand assemblies and the storage, grinding and assembling of equipment such as guides and strippers, which have built-in alloy steel rollers to minimise abrasion.

A two-storey extension block, 200ft long and 30ft wide, on one side of the main building, contains all the electrical equipment for the mill, as well as office accommodation. The cable system installed in the basement of this block includes some 32 miles of B.I.C.C. cables and in this system P.V.C. armoured multi-core power cable is used for the first time in a mill. The basement also houses the ventilation plant which is pressurised by three motor-driven fans incorporating filters ; further booster fans divert some of this air through ducts to cool the mill motors.

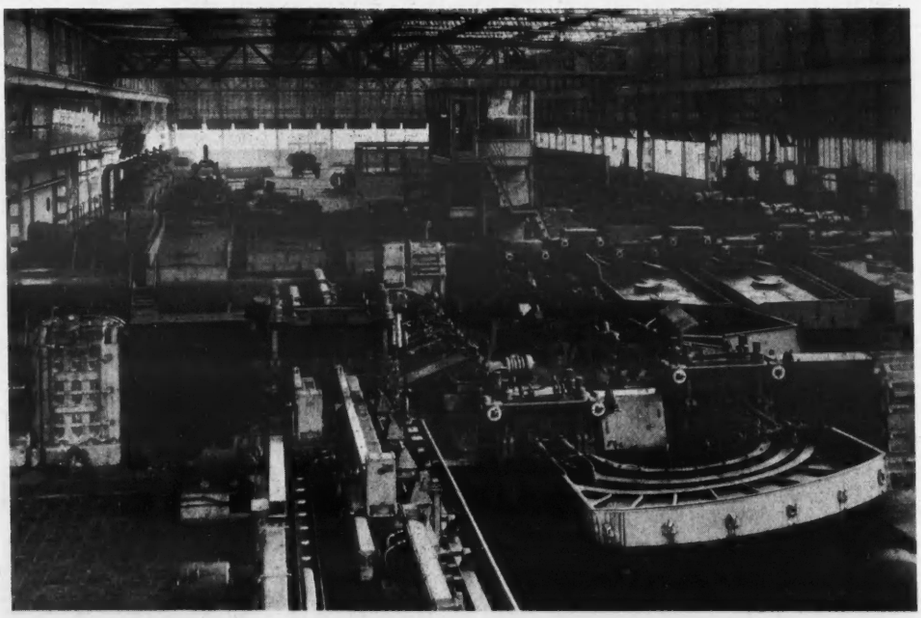


Fig. 4—General view of rolling mill with 20in roughing mill in left foreground and 15in two-stand roughing mill on its right. The duplicate intermediate finishing mills can be seen on each side of the central pulpit

Progress in Electric Lamps*

By H. G. JENKINS, M.Sc., F.Inst.P.†

During the past twenty-five years there has been spectacular progress in the development of electric lamps. While this applies mainly to discharge sources, much work has gone into incandescent lamps, which, despite their relatively low luminous efficiency, have not diminished in importance. An entirely new method of converting electrical energy into light by electro-luminescence has been evolved, which, however, has not fulfilled its early promise. On the other hand, at a time when progress in conventional discharge sources might reasonably be expected to have levelled off, new ideas have evolved and substantial improvements have been made. This paper discusses the more important developments and trends in the field of electric lamps; extracts are reproduced below.

Tungsten Lamps

The Tungsten-Iodine Cycle.—Perhaps the most important development of recent years in filament lamps is the deliberate use of chemical mechanisms in the lamp to improve lamp performance. Solely physical processes, filament temperature and evaporation characteristics of tungsten in an inert gas atmosphere, have heretofore controlled the light output and have given tungsten lamps their well defined efficiency-life relationships.

In 1915 Langmuir described the influence of chlorine on incandescent tungsten[1] and noted that if incandescent and "cold" tungsten wires were placed side by side in a chlorine atmosphere the hot wire would increase in diameter at the expense of the cold wire which would eventually disappear. During the following thirty years there appeared further references in the literature to the addition of halogens or halogen compounds to tungsten lamps. In 1953 a study of the influence of iodine on the arcing characteristics of G.L.S. lamps was started at Wembley, where it was noted that when a fair quantity of iodine was added to the normal gas filling in a lamp a very pleasantly tinted pink lamp was produced whose colour remained stable and whose life was greater than expected.[2] This was a most interesting result since it showed, contrary to expectations, that a practical incandescent tungsten filament could be operated satisfactorily in an iodine atmosphere provided that the usual nickel support leads are replaced by molybdenum. Other halogens were unsatisfactory because of their considerable reactivity, even with molybdenum.

At about this time the G.E. of America were developing the quartz tubular infrared lamp with a tungsten filament which, because of rapid and serious bulb blackening, looked singularly unpromising as a light source. They began to explore the potentialities of iodine and discovered that with iodine present the quartz tube remained quite clean even when the nearby tungsten filament was at a temperature of 3000 deg. Kelvin.[3] This remarkable effect has since received much study, both in this country and abroad. It is now known that for the effect to occur three conditions must be satisfied, namely, the wall temperature of the enclosure must be over 250 deg. Cent., its size and shape must be such that the gaseous convection currents within the lamp are negligible, and the chemically reactive components within the enclosure must be confined to tungsten and iodine. These reactive constituents, in the possible presence of an inert gas, form a closed chemical system in which the tungsten and iodine components are continually combining and dissociating. The iodine prevents tungsten condensing and remaining on the envelope by forming a tungsten-iodine compound which remains in the vapour state and diffuses through the lamp volume. This compound does not dissociate until it reaches a temperature of over 1600 deg. Cent. in the neighbourhood of the filament. When dissociation occurs it has, therefore, the effect of increasing the pressure of tungsten vapour near the filament, so reducing the evaporation rate. Thus, in addition to making possible a nearly perfect lumen maintenance, the tungsten-iodine mechanism improves the lamp life by reducing evaporation of tungsten. The temperature and convection condition mentioned above for the operation of the iodine cycle necessitate small envelope size and point to quartz as the most suitable material.

Practical Tungsten-Iodine Lamps.—There are likely to be many repercussions from this development in our thinking on lamps and lighting. It offers us, for example, extremely small, high brightness lamps of outstanding performance for 8mm or 16mm ciné projection. This type of lamp used with a small, short focus elliptical reflector makes possible a highly efficient arrangement in which the lamp and its optical system are separate with all the advantages this entails of economical lamp replacement. Fig. 1 shows (left) an experimental lamp of 12V, 100W rating developed at Wembley, in comparison with the much larger conventional glass lamp (right) of the same wattage.

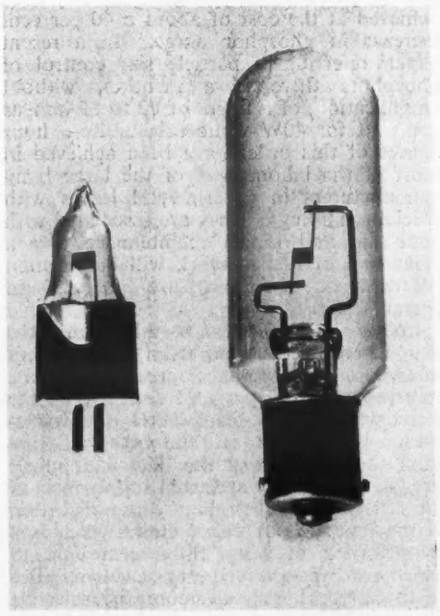


Fig. 1—Experimental 12V, 100W quartz-iodine projector lamp compared with conventional lamp

Another possibility is in a similar lamp used with a small short focus reflector for spotlighting or floodlighting.

Quartz tubular iodine lamps of higher wattage can be used for many applications of sports field lighting and floodlighting where the new source gives, in addition to a better performance, marked advantages in the size and cost of the fitting. Yet another way in which this development may affect our thoughts is in the field of tungsten ballasted high pressure mercury lamps.

Lamp Manufacture and Performance.—Although there has been continuous improvement in almost every aspect of lamp quality, much still remains to be done to improve the uniformity of lamp performance. The magnitude of the problem is apparent when it is realised that a change of only 1 per cent in the diameter of wire in the length of a single filament, can reduce lamp life by over 25 per cent compared to that using a perfectly uniform wire.

Other Temperature Emitters.—Tungsten, with a melting point of 3653 deg. K, is the most refractory metal known. This characteristic more than anything also determines the efficiency-life relationship of tungsten lamps and leaves little room for spectacular improvement. The properties of tungsten compel its use in the form of a long, relatively fragile coiled wire, which further limits its performance as an incandescent body. The discovery of the tungsten-iodine cycle opens up considerable possibilities for improved performance in certain types of lamps, but to achieve much higher efficiencies from a temperature emitter it will be necessary to discover a more refractory conductor than tungsten and preferably one which emits selectively and which can be used in the form of a thick rod.

Certain metallic carbides, notably tantalum carbide, are conducting and have melting points higher than tungsten.[4] A special type of projector lamp using a disc of tantalum carbide, heated to incandescence by eddy current heating from a radio frequency generator, has been demonstrated in the United States.[5] Another method of heating which is being studied is by electron bombardment, which may have application in heating highly selective emitters such as thoria and other semiconductors. While all this work is of great interest there is nothing to suggest it is likely to lead to an important substitute for tungsten in the near future.

Fluorescent Lamps

It is now just over twenty years since the fluorescent lamp in the form in which we know it was marketed in the U.S.A. It is just as well to remind ourselves that much of the basic work leading up to this event was done in Europe, and indeed this country can claim a major share in the credit for the development of this remarkable light source.

The 5ft 80W Fluorescent Tube.—The first British fluorescent lamp to operate directly from a mains voltage supply was marketed in 1940 although experimental lamps of various sizes were already well advanced in the laboratories of some of the larger British lamp companies as early as 1937.‡ At that time high-voltage fluorescent lamps were already well established for lighting purposes in this country.

The first British mains voltage lamp was the well-known 5ft 80W lamp which was hurriedly introduced to meet the needs of

* Illuminating Engineering Society, Summer Meeting, Harrogate, May 15–18.

† Research Laboratories, The General Electric Company, Ltd., Wembley.

‡ It is worth recording that the lounge of the author's home in Pinner was lit with cold cathode fluorescent and neon tubes as early as 1935. The colour rendering from the combination compared favourably with anything available to-day.

wartime Britain ; because of the excellence of the design it became, and still remains, the most important lamp in this country. In 1942 the efficiency was 35 lumens per watt for the "Daylight" colour and a life of 2000 hours. The efficiency is now greater than 60 lumens per watt, although it is only fair to say that about 25 per cent of this increase in efficiency can be accounted for by the change in the spectral distribution of the light which occurred when halophosphates were introduced in 1945. The discovery of this family of phosphors at Wembley in 1942 is probably the greatest single contribution to fluorescent lamp progress since its inception. The life of the lamp is to-day certainly closer to 8000 than to 5000 hours. Failures before 4000 hours are exceptional.§

Performance.—In 1942 it was shown from theoretical considerations that the maximum efficiency to be expected from a low pressure fluorescent lamp was 60 lumens per watt for a colour close to that of natural daylight.[6] There is still some way to go to achieve this performance but the gap is being filled more rapidly than might have been expected.

The improvement in the average efficiency throughout the life of the lamp, now usually taken as the efficiency after 2000 hours' burning, has been even more marked than the gain in initial efficiency. This is the figure that really matters to the user and in an ideal lamp it would be no lower than the initial value. It is a pity that the practice throughout the world is to stress initial values rather than average. Most people who think about this matter at all will agree that of two lamps having the same life and average efficiency, but different initial efficiencies, the one with the lower initial value is the better ; and this is true for all lamps, not only for fluorescent tubes.

How have these improvements in performance been brought about ? The life is mainly a function of the filamentary electrodes, each of which carries about 15 mg of electron emissive material in its coils. This comprises a mixture of alkaline earth carbonates which are subsequently decomposed to the oxides during the processing of the lamp. It is of great importance that the coating of oxides on the filament should emit electrons freely and that it should be firmly retained in the coils of the filament during operation. Attention to both these matters has, more than anything else, contributed to the excellent life performance of the lamp. The emissive material is gradually removed from the cathode while the lamp is burning and when no more remains the discharge will not start. There are other causes of failure, but this is the usual one.

The gain in luminous performance has arisen mainly from a steady improvement in the quality and particle size distribution of the fluorescent powder, used for coating the inside of the tube. This, in itself, would have had little effect without corresponding improvements in the lamp manufacturing processes and equipment.

The Fluorescent Coating.—The phosphor as it comes from the furnace is a lightly sintered powder which has to be milled and suspended in a binder to enable a thin coating to be applied to the tube. The particle size distribution of a typical phosphor is shown in Fig. 2 (curve *A*) from which it will be seen that the range covered is from about 1 to 30 microns. It will be apparent that the coating must effectively prevent any u.v. radiation from the arc reaching the glass wall of the tube, where it would be absorbed and wasted. The optimum coating density is achieved at about 7·5 g of powder per 5ft 80W tube with the distribution shown. For economic reasons it has been usual to work slightly below the optimum at about 5·5 g per tube. It has long been known that the very fine particles in the phosphor below 3μ have a low intrinsic efficiency. Moreover, because they tend to form a u.v. absorbing coating over the larger crystals they have a disproportionate effect in reducing the efficiency of the lamp. The distribution curve *B*, shown by the full line in Fig. 2, is that of the same phosphor classified by removing the ultra fine particles and some of the coarse. One important method of doing this is to pass an aqueous suspension of the milled powder through a hydrocyclone shown diagrammatically in Fig. 3. The suspension enters at *A*, tangential to the inner surface, at a high velocity and flows down the cyclone in a spiral depositing the large particles on the walls from which they pass out through the orifice *B*. The finer particles are carried up the inner tube and out through *C*. A number of cyclones can be used in series to improve the separation. In the full process the coarse fraction is remilled and reclassified, thus effectively cutting from both ends of the distribution. This technique is capable of handling many kilos of phosphor per hour with relatively simple equipment.

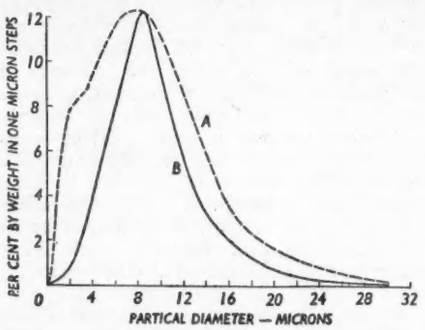


Fig. 2—Particle size distributions of phosphors

The use of classified phosphors has given an overall improvement in efficiency of about 10 per cent. Unfortunately, because of the losses in the classification process, and the increased coating density due to the higher average particle size, this gain has only been achieved at the cost of about a 40 per cent increase in phosphor usage. In a recent paper[7] referring to particle size control of phosphors there is a mention, without amplification, of a figure of 80 to 85 lumens per watt for 40W white tubes. Zero hour figures of this order have been achieved in most of the laboratories of the large lamp manufacturers in experimental lamps with special gas fillings. They are associated with poor life and lumen maintenance and a great deal of further work will be required before such efficiencies are obtained in normal lamps.

Colour Characteristics.—Although the major part of the light from a fluorescent tube comes from the fluorescent coating, something like 10 per cent comes from the mercury vapour discharge. In the warm-colour lamps there is little blue radiation from the coating and the blue and purple lines in the mercury spectrum supply most of the blue light. These lines cause distortion of the rendering of blue colours which is a characteristic of warm fluorescent light to which some people are very sensitive. The effect can be largely overcome by selective filtering of the mercury radiation, either in the lamp itself or in the fitting ; double-coated lamps of excellent colour have been introduced in which the coating in contact with the tube wall acts as a filter for the blue mercury lines. It is possible by this technique to reproduce fairly accurately the colour appearance and the colour rendering characteristics of both low and high temperature tungsten filament lamps.

Highly Loaded Lamps.—Until a few years ago when lamps of similar loading were announced in the U.S.A., the 5ft 80W tube had the highest loading of any fluorescent lamp in the world. The British 8ft 125W lamp had the highest lumen output. It would have obvious advantages if, for example, the wattage of a 5ft 80W lamp could be increased to some higher value without any reduction in life or efficiency. This is not simply a matter of increasing the current through the tube, which causes a reduction in the tube voltage and requires a disproportionately large current increase to give the required high wattage ; this adversely affects both life and efficiency.

In 1957 two highly loaded fluorescent tubes, one of novel design, were introduced in the U.S.A.[8, 9] These designs take account of the well-known fact that high current density and high mercury vapour pressure both lead to reduced efficiency. Unduly high current densities are avoided in both types of lamp by keeping the tube voltage as high as practicable. In one type this is done by adding neon to the usual argon filling gas ; in another type the tube cross-section is made kidney-shaped to bring the discharge into closer proximity with the tube walls. This reduces the effective diameter of the tube without affecting the surface area. Limitation of mercury vapour pressure is achieved by keeping a part or parts of the tube at a lower temperature than the main part. It is the temperature of this cooler region which determines the vapour pressure and not the highest or average temperature of the tube.

The life and luminous performance of these and other highly loaded lamps which have been marketed in America and in Europe are poorer than obtained with normal tubes ; it cannot be said that a fully satisfactory solution to the technical problems associated with high loading has yet been found. The technique of vapour pressure control brought out by these developments may prove to be of value as a method of increasing the tube voltage of the 5ft 80W lamp ; this tends to be lower than desirable particularly when the ambient temperature is high.

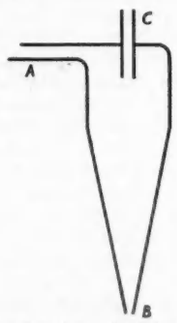


Fig. 3—Principle of Hydrocyclone

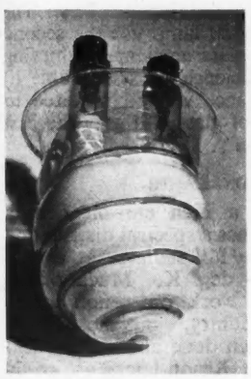
Compact Fluorescent Lamps.—Another method of making the source more concentrated is to make the long discharge path, which is an essential feature of the low pressure fluorescent lamp, follow a zig-zag or spiral course. This rather old idea is being revived, particularly in the U.S.A., where a flat fluorescent lamp has recently been announced[10] although it is not yet on the market. Fig. 4 shows an American

§ The large manufacturers have such faith in their product that they guarantee to replace, free of charge, any fluorescent lamp which fails before 3000 hours or a year's burning.

lamp of this type (*b*), together with an early experimental British compact lamp (*a*), developed some years ago but never marketed because of its rather high manufacturing cost. The flat lamp is made from a mould-blown component having a depression of semi-circular cross-section defining the discharge path. This is closed by sealing a flat plate to it, as shown in the photograph. The British lamp is made from two mould-blown components, shaped so that when sealed together, one inside the other, a spiral path for the discharge is formed. In both designs the discharge path is some 3ft long and gives about the same luminous output as a 4ft 40W lamp. It is interesting to speculate whether the flat shape will enable the fluorescent lamp to make any impact on the domestic market which has hitherto relegated it to the kitchen or the garage.

Reflector Lamps.—The luminance of a fluorescent tube can be increased by silvering the back half of the tube. Some years ago it was proposed to use, instead of a metallic mirror, a coating of a white powder between the glass wall and the fluorescent coating.[11] A fluorescent lamp of this type was marketed in this country in 1956.[12] The reflecting surface is a thin coating of titanium dioxide which also reflects well in the ultra-violet. The reflecting coating is first applied over the whole tube and before the fluorescent coating is applied a strip of the titania coating, about one-third of the circumference in width, is removed. This serves as a window through which about 90 per cent of the light from the tube passes. Most of the remainder passes through the reflector coating. Fig. 5 shows the polar diagram of a typical reflector tube. Tubes of this type are finding useful application in dusty and dirty situations where it is difficult to keep the tube clean ; a deposit of dust on the reflector causes much less loss of light than it would do on a normal tube. A recent report from the U.S.A. mentions a newly developed so-called aperture lamp which appears to be a form of highly loaded reflector tube. It is claimed that the luminance of the aperture is 22,000ft-lamberts, and it is expected to find use for bridge and tunnel lighting, floodlighting, and even for automobile headlamps. There is insufficient information available to enable these claims to be judged.

Circuits.—Perhaps the most interesting new circuit development is the germanium transistor inverter for obtaining a.c. from a battery supply, which is particularly applicable to transport lighting. This development has been well described in a recent paper.[13] A new type of semiconductor device, the silicon controlled rectifier, is capable of handling much higher power and of operation from a higher d.c. voltage. It is perhaps not too much to hope that this type of semiconductor will be developed to operate in a frequency-changer circuit giving, say, a 10,000 cycle output from a 50-cycle input. Such an arrangement might make high frequency operation, with its attendant advantages of cheap, lightweight control gear, freedom from stroboscopic flicker and improved lamp efficiency, a practicable proposition.



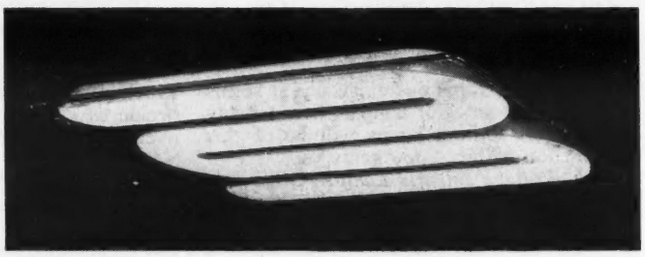


Fig. 4 (*a*) left and 4 (*b*) above—Experimental compact fluorescent lamps

High-Pressure Mercury Vapour Lamps

Increasing the mercury vapour pressure in a fluorescent lamp above the optimum value, which occurs at a temperature of around 40 deg. Cent., adversely affects efficiency because of the reduction in the intensity of the important u.v. line at 2537A. If the electrical loading of a mercury discharge is increased to, say, 50W per centimetre length of 25mm diameter tubing the tube wall reaches a temperature of about 600 deg. Cent., and the mercury vapour pressure rises to several atmospheres if sufficient mercury is present in the tube. Under these conditions a much higher proportion of the energy in the discharge is radiated in the visible part of the spectrum and the luminous efficiency is increased by a factor of 8 to 10.

Energy Balance in an H.P.M.V. Lamp.—An examination of the energy balance in a 400W quartz H.P.M.V. discharge shows that about 16 per cent is emitted in the visible region and something like 23 per cent in the ultra-violet between 2000 and 3800 A.U. Only about 9 per cent is emitted by the arc in the infra red but about 38 per cent is lost by convection and conduction of heat from the arc tube ; the remainder, amounting to 14 per cent, is lost at the electrodes. The principal factors affecting the luminous efficiency of the arc are mercury vapour pressure, arc length, arc tube diameter and the wattage loading. There is little room by varying these parameters for other than minor efficiency improvements, except under laboratory conditions.

Fluorescent H.P.M.V. Lamp.—The most important developments in the H.P.M.V. lamp have been concerned with the utilisation of the u.v. energy by means of fluorescence to improve colour and efficiency. There are no phosphors known which will withstand the temperature of an H.P.M.V. discharge tube. It is, therefore, necessary to apply the coating to the inside of a fairly large bulb surrounding the discharge envelope. Lamps of this description have been in use in this country since 1937 but the early phosphors gave only a rather small degree of colour correction. A number of phosphors having the desired temperature, excitation and emission characteristics are now available. The most important of these, magnesium germanate,[14] gives a remarkable emission in the red, a region in which the H.P.M.V. discharge is deficient, and a high degree of colour correction with little or no loss in luminous efficiency. A lesser degree of correction, but a gain in efficiency of perhaps 10 per cent, is obtained with strontium zinc phosphate,[15] which emits mainly in the yellow-orange region.

Magnesium germanate has a weak absorption band in the blue region and this tends to give the lamp a greenish appearance unless rather thin coatings are used. Attempts to compensate for this by using a tinted outer bulb absorbing in the middle region of the spectrum have been reasonably successful, but this subtractive method of correction involves a loss in efficiency.[16] At the relatively low levels of illumination usual in most streetlighting installations, colour discrimination is poor and some people appear to have difficulty in distinguishing colour corrected H.P.M.V. lamps from the uncorrected type. It is possible, therefore, that the main demand for the colour corrected lamps will be for streetlighting at fairly high illumination levels, such as are obtained at present with tubular fluorescent lamps, at places such as important shopping centres.

A modification of the usual colour corrected lamp has established itself in the U.S.A. and is finding some application over here. In this, the outer bulb is similar to the well-known reflector bulbs in the tungsten lamp range. The fluorescent coating is applied on top of an internal vaporised metallic or powder reflector on the sides of the bulb. The bottom surface of the bulb is left uncoated but is etched to diffuse the light from the arc.

Tungsten Ballasted H.P.M.V. Lamps.—H.P.M.V. lamps have often been used in conjunction with tungsten lamps to improve the colour of the discharge or to eliminate the usual series choke, or for both reasons. When used in place of the choke the usual practice has been to mount the tungsten filament in the same outer bulb as the discharge tube. If it is intended to make a useful contribution to the light output and not merely to act as a ballast, the design of the filament is a matter of compromise, since it must withstand the high current during the run-up period of the discharge and have a life comparable with that of the discharge itself. A range of combined lamps of this description, in which the outer bulb is coated with magnesium germanate phosphor has been reported in the U.S.A.[17] These are 450W, 750W and 1750W and are claimed to have initial efficiencies around 30 lumens per watt with a red ratio similar to that of standard illuminant C (full radiator at 6500 deg. K).

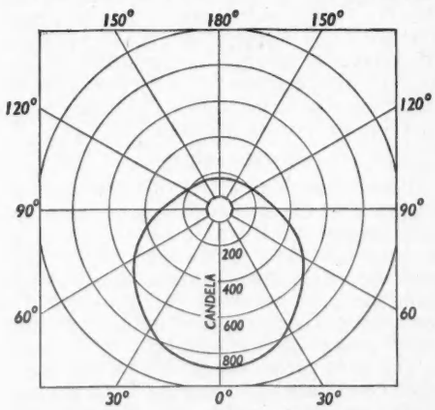


Fig. 5—Polar diagram of 5ft 80W reflector tube

A study of this problem has shown the

possibility of making an improved tungsten ballasted H.P.M.V. lamp using the new quartz tungsten iodine lamp discussed earlier.[18] The shape of the source is compatible with that of the discharge tube, which enables the two lamps to be placed in close proximity, giving rapid heating of the discharge and correspondingly short run-up time. For the same reason, good mixing of the light from the two sources is readily achieved. Also, the performance of the tungsten iodine lamp is much superior to that of a similar filament processed and operated under the unfavourable conditions inside the outer bulb. It is to be expected that this approach to the problem will lead to a tungsten ballasted H.P.M.V. lamp of excellent efficiency, colour and life.

Colour Modification of the Discharge.—Another method of modifying the colour of H.P.M.V. lamps is by the addition of zinc and cadmium to the discharge. Both these metals have an appreciable vapour pressure at the temperature of the bulb and each contributes characteristic arc lines to the mercury spectrum. The blue emission from zinc, added to that of a fluorescent H.P.M.V. lamp, gives a colour not dissimilar to that of the xenon arc. Experimental lamps of this type were demonstrated recently[19] but because of zinc attack on the quartz envelope cannot yet be regarded as practical sources.

Pulsed H.P.M.V. Ciné Projection Lamp.—An interesting new H.P.M.V. lamp for ciné film projection was announced last year.[20] This comprises a water-cooled high pressure mercury lamp having an arc length of 17mm in a quartz tube about 5·5mm in diameter. The quantity of mercury in the lamp is restricted to a small controlled dose which is practically all vaporised when the lamp is in operation. The discharge is pulsed in synchronism with the moving film so as to give three short-period flashes, each of about 2·5 milliseconds duration, per frame. No shutter is required in the projector. Thus at twenty-four frames per second the lamp is flashing at a frequency of seventy-two per second, which ensures a reasonable freedom from flicker. The peak current per pulse is about 15A and the mean power consumed by the lamp is 800W ; the luminous flux on the screen equals that of a 60A carbon arc. Because of the very high instantaneous loading the spectrum of the emitted light contains a high proportion of continuum and the source is stated to be excellent for projecting colour film.

Sodium Lamps

The sodium lamp is one of the earliest of the hot cathode lamps. Much of the basic development work was done in Germany and the U.S.A. before the war. No significant use of the lamp has been made in the latter country, no doubt partly due to the poor design of lamp evolved to suit their series system of streetlighting.

The chief attraction of the sodium lamp is, of course, its high luminous efficiency and there are considerable improvements to report. The theoretical maximum efficiency of the sodium vapour discharge is certainly greater than 300 lumens per watt so that there is still scope for further gains. It is safe to assume that the final word on the subject has not yet been said.

Integral Construction.—After a long period of stability the past few years have seen much development in sodium lamps. This has been confined entirely to this country and Europe, and may be said to have begun with the development over here of the now well-established integral lamp, in which the detachable dewar flask is replaced by a single-walled tubular jacket, into which the discharge tube is permanently sealed, and the jacket highly evacuated.[21] The limbs of the U-tube are fitted with glass sleeves before sealing in, which help further with the conservation of heat from the discharge. Elimination of the dewar flask in the integral construction simplifies installation, cleaning and replacement of lamps. The discharge tube is completely protected from the atmosphere and difficult starting under conditions of high humidity is eliminated, as is the problem of deciding when to renew the dewar flask, which gradually deteriorates with use. For these reasons, and because the more effective heat conservation makes possible higher luminous efficiency, it seems likely that the integral lamp is here to stay and that all sodium lamps will be of this construction within a few years.

TABLE I—*Luminous Data for Sodium Lamps*

Type	Watts	Initial lumens	Average lumens (4000 hours' life)
U-bend with Dewar jacket	45	2,610	2,250
	60	4,020	3,420
	85	6,200	5,525
	140	10,200	9,100
U-bend with integral jacket	45	2,650	2,295
	60	4,120	3,540
	85	6,800	5,950
	140	11,200	9,800
	280*	25,200	22,400
Linear with integral jacket	200	20,000	18,400

* Double U-bend lamp.

High Wattage Integral Lamp.—Other ratings of integral lamps have more recently been proposed. The first high wattage type to be marketed in this country consisted of two 140W U-shaped discharge tubes sealed into the same outer jacket.[22] Heat-reflecting sleeves are not required with this construction. The lamp has the same external dimensions as the 140W integral lamp, but is fitted with a stout four-pin cap and each inner may be operated independently of the other. In yet another design the two 140W U-bends are placed end-to-end in a long tubular envelope.[23]

A complete break-away from the existing design of discharge tube has been made in one design, rated at 200W, which uses a straight arc tube of non-circular cross-section with lengthwise grooves or depressions separated by short lengths of tube of circular cross-section after the manner of the American " Power Groove " fluorescent tube.[24] The lamp is capped at each end with bi-pin fluorescent lamp caps, which enable the filamentary cathodes to be preheated in a starting switch circuit or by a filament heating transformer.

Sodium-Resistant Glass.—Because of the intense chemical activity of hot sodium vapour it is necessary to use a special glass for the discharge tube which will withstand attack by the vapour. It is usual for this protective glass to be applied as a thin flashing on the inside of an ordinary glass tube. Sodium resistant glasses are of two main types : those which absorb sodium and those which do not. The absorbed sodium shows as a dark film on the surface of the glass which causes some loss of light. On the other hand, this film provides a uniform supply of sodium vapour throughout the length of the discharge tube and effectively overcomes the tendency to local sodium starvation due to mechanical and thermal movement of the sodium during operation of the lamp. Moreover, the absorbed sodium appears to reduce the loss of argon from the gas filling which occurs during operation of the lamp and which, if allowed to proceed too far, results in failure due to the inability of the lamp to start. It is possible to delay the effects of thermal movement or migration of the sodium in non-absorbing glasses by modifications to the cross-sectional shape of the discharge tube. The effect of clean-up of argon can be reduced in some measure by adjustment of the filling gas composition and pressure, but neither sodium migration nor gas clean-up in non-discolouring resistant glass have yet been wholly overcome.

The early integral lamps used, and continue to use, glass of the first type which, although not giving the highest initial efficiency, is substantially free from sodium migration and argon clean-up troubles. The newer types of integral lamp use the second type of resistant glass and are achieving improved initial efficiencies. (See Table I.) Much more experience will be required to decide which type of glass will give the best overall performance.

Xenon Lamps

The light from a high current density discharge in xenon has a spectral distribution similar to that of a full radiator at a temperature near 6000 deg. K. Much of the early development work on xenon lamps was done in this country,[25] but most of the recent work has been done abroad, particularly in Germany.[26] Xenon lamps are costly to manufacture and because of the high ratio of starting to running voltage require rather bulky and expensive control equipment. Despite their excellent colour characteristics, the lamps have, for these reasons, not come into widespread use.

Types of Lamp and Performance.—Development has followed two main lines : the short arc length, high luminance type, and the long arc length, relatively low luminance type. The former, which are used mainly for optical projection work, may be filled to a xenon pressure as high as 10 atmospheres measured at room temperature. The long arc length lamps are usually filled to a fraction of an atmosphere pressure and are used for general lighting.

Short arc length, air cooled, high pressure lamps are available from 160W rating up to 2½kW. The higher wattage compact source types are used mainly for film projection, both black and white and coloured, which has been, until recently, the only really important application for xenon lamps. A British 2kW lamp for 16mm and 35mm film projection is now available.[27] It is filled to 4 atmospheres cold, corresponding to 10 atmospheres when in use, has an arc length of 8·5mm and an average arc luminance of 25,000 stilb. The 160W lamp has found

TABLE II—*Characteristics of Xenon Lamps*

Data for short-arc, air-cooled lamps :			
Input (watts)	500	1,000	2,000
Approximate operating current, (A)	28	57	112
Approximate arc length (cm)	0·28	0·28	0·35
Arc width of 10 per cent axial brightness (cm)	0·26	0·30	0·42
Arc luminance at centre of arc (stilb)	15,000	25,000	25,000
Bulb diameter (cm)	4·1	5·0	7·0
Data for high wattage, long-arc, air-cooled lamps :			
Input (kW)	20	65	—
Operating current (A)	75	250	—
Arc length (cm)	190	240	—
Tube diameter (cm)	3·0	5·0	—
Lumen output (lumens)	560,000	1,940,000	—
Luminous efficiency (lumens/watts)	28	30	—

some application in Germany for colour matching. The long arc length lamps are used mainly for stage and other special lighting applications and their use appears to be on the increase. Lamps of 6kW, 10kW, 20kW, and even 65kW rating are available on the Continent. The latter lamp uses a quartz tube 8ft long and 2in in diameter; it operates at a current of 250A and has an efficiency of 30 lumens per watt. Such a lamp must necessarily have limited application. One of the most spectacular installations is that in a square in Munich, comprising three 20kW lamps mounted on a column 100ft high. The total luminous flux from the lamps amounts to $1{\cdot}6\times10^6$ lumens and the average illumination is 10 lumens per square foot over the square. Table II gives the main dimensional and other characteristics of the 20kW and 65kW xenon lamps.

Much work has yet to be done on these interesting sources to simplify their manufacture and operation and to make them more acceptable for general lighting applications. It is at least uncertain whether this type of source could, for general lighting purposes, ever seriously compete with the simpler and cheaper tungsten filament lamps, with their warmer colour and comparable luminous efficiency.

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Continental Machine Tool and Production Engineering Laboratory

TECHNOLOGICAL UNIVERSITY OF AACHEN

By C. ANDREW, M.A.*

The Machine Tool and Production Engineering Laboratory of the Technological University of Aachen is the largest and best-known centre for the work of its title in Western Germany. The author spent a few days there recently, seeing the work in progress and discussing it with the research staff; this article deals briefly with the structure of the research programme and its relation to the teaching activities of the department, and summarises the work in hand as an indication of its nature and range.

THE Technological University of Aachen consists of an association of faculties covering a wide range of scientific subjects; housed in imposing modern buildings set in the "University Quarter" of this ancient German border town, it serves a cosmopolitan student population of over 8000. The Machine Tool and Engineering Production Laboratory is led by Professor H. Opitz, Dr.-Ing., heading a team of over forty graduate research engineers, backed up by undergraduate assistants and the associated skilled workshop staff, and technicians.

One of the first impressions on entering the Laboratory's modern building is of the lofty machine shop running the full length, with offices, instrument rooms, subsidiary workshops, &c., feeding off galleries along both sides. With a floor space of some 8000 square feet, this machine hall contains a mixture of standard machines, frequently in use for the testing of cutting materials and conditions, special research apparatus for somewhat more basic investigations into machine tool elements, and prototype machine tools undergoing tests and development.

The laboratories and offices feeding into the main hall are devoted predominantly to research staff and equipment. An indication of the emphasis placed on research in this University department is that the space devoted to it is four times that of the lecture theatre, drawing-office, &c., used for teaching purposes. A novel use for a massive concrete air raid bunker is to house apparatus for the acoustic testing of running gearboxes, in suitable isolation.

The sources and distribution of income further emphasise the place of research in the department's activities. Roughly, 30 per cent of the annual income comes from the University, and ultimately the State, for teaching and fundamental research. The remainder is devoted wholly to research, and consists of about 30 per cent from the Regional and Federal governments, 15 per cent from a National Research Association (Deutsche Forschungsgemeinschaft, known as D.F.G. and equivalent to our Department of Scientific and Industrial Research) and a significant 25 per cent directly from industry in the form of grants and commissions for specific projects. Of the forty to fifty graduate engineers employed on the various fields of research, about ten are paid as civil servants from the department's governmental incomes. The salaries for the others arise directly from industrial sponsorship, from projects financed by the D.F.G. or from the commissions of industrial associations.

The close liaison with industry and its problems is an essential feature of the functioning of the department. As well as the financial aspect, regular discussions of current problems are held in an effort to sort out the most fruitful fields of research, and where apparatus is required in the form of a machine tool, this is frequently loaned by the maker. This may well account for the applied nature of much of the research, as will be evident from consideration of the work in hand. Thus, a company can use the Laboratory effectively as an efficient and experienced research department; they have devoted to their problem the services of a graduate engineer who works hard and comparatively cheaply in the knowledge that the task can be the means of his own academic distinction—his doctorate or his "name."

Moreover, in a few years' time there is a highly trained research engineer whose particular interest is their problems; potentially a very valuable employee; this is a situation that at first sight could be an embarrassment to the department, as it seems that in practice industry is not slow to take advantage of it, the low average age of the research assistants being witness. However, there is no doubt that the long term result is beneficial to all parties concerned, industry, the research worker, and the department. It is a tribute to the farsightedness and diplomacy of the Laboratory's leadership that it is able to make such a significant contribution to the machine tool industry as a whole.

TEACHING ACTIVITIES

There are available through the department courses of lectures directed towards the science of machine tools and production engineering, open to students who have completed satisfactorily the first two years of their four years of formal teaching for the "Diploma Ingenieur," these being two years of more general scientific instruction. Students must have evidence of satisfactory school careers and have completed six months' industrial workshop experience before being eligible for entrance. After passing the candidate examination, about thirty students, while continuing their regular teaching course, will work as "Hilfsassistants," helping part-time the permanent research assistants in a small section of their main problem. This work consists of a minimum of 100 hours per month, and is often paid for from project funds. In this way their formal engineering course can include training in research, associated with a taste of what a future career in engineering research might entail, and some useful help in the problem itself.

On completion of his four years of formal teaching, the student embarks on a "Diploma Arbeit," a research project of at least three months' duration which he must perform and report on satisfactorily as a requirement for his degree. Thus the department sets out to include training in and by research as a significant part of its curriculum in an effort to produce engineers suited to tackle the many new problems arising in its science.

RESEARCH ACTIVITIES

The summary of the work in progress given here is intended to give a fair indication of the scope and type of project being investigated. A bibliography of the department's publications is appended.

Machine Structural Elements.—The achievement of high accuracy of the finished product, coupled with high machining rates, low first costs, &c., is dependent, among other things, of course, on distortion of the machine structure due to static and dynamic loading and temperature variations. This has led to a comprehensive programme of structural testing of machine elements and their combinations.

The use of plastic models as a relatively

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cheap method for predicting the behaviour of the full scale element, and subsequent use in design optimisation, is under investigation with the necessary study of the properties of the materials and their suitability for the task—adhesives and easy shaping.

Tests on steel models have been under way for some time, with successful application of the results. The effects, static and dynamic, of cut outs, fillets and the techniques and designs for the fabrication of welded plate machine structures have yielded some interesting information on the relative merits of welded box sections and cast elements. The effectiveness of vibration absorbers, with optimisation of the various controllable parameters involved in their use, is being investigated with model structures, using the usual dynamic forcing and measuring equipment.

Full scale spindle and bearing tests on a specially designed rig are used to indicate how, for example, the stiffness at the working section of a lathe can be improved. They indicate the optimum lay-out, taking into account different bearing and spindle stiffnesses; also the increase in damping and stiffness achievable from shrinking a sleeve on to the spindle.

Bearings naturally come in for a close inspection; the variation of stiffness with preload and roller size, and the importance of the bearing housing; the life as a function of running speed, load, preload, and lubrication. Since the running temperature of a bearing is important, not only with regard to breakdown of the lubricant but also the distortion of the surrounding structural elements due to temperature gradients, tests are run to find the heat production as a function of the speed, preload, lubricant type, &c. Also the feedback of running temperature on preload, due to unequal heat conduction from inner and outer races. Different methods of lubrication are tested, including optimisation of the low temperature advantages of oil mist.

Gear Noise and Vibration.—There is an extensive programme of testing on gears, their functioning, and their manufacture which has required development of special techniques and equipment.

At the machining stage, the gear hobbing machines are examined for irregularities of table motion, giving rise to pitch variation; this is done with very low frequency seismic torsional pick ups, the natural frequency being in the order of 0·15 c/s. The irregularities are then analysed and traced back to the offending gear train in the machine, or to variation in driving speed. These instruments are very sensitive yet can be used quickly and without stopping production. For larger machines where table pitch discrepancies are too low a frequency to detect, a rig has been developed to run a gear pair with seismic pick ups on both driver and driven shafts, with subsequent subtraction of the output signals for analysis.

A second approach in the investigation of gear errors is the method of analysis of the acoustics of a running gearbox. A gearbox unit is placed in an acoustic room—with reflecting rather than absorbing walls—and the sound output picked up by a microphone and recorded on tape. From a highly developed system of filters and re-recording, the sound energy output can be plotted against frequency, and the offending frequency ranges can be used as an indication of the irregularities in the gears, and hence in the gearmaking machinery. This technique can also be applied *in situ*, as in the case of a shipboard reduction unit tested under operating conditions.

Complementary with these error investigations is a programme of wear testing, when the gear sets are included in a train with a controllable internal couple present. The couple can be varied from zero up to 80 kg metres, with speeds up to 3000 r.p.m. and tests are run varying load, speed, lubricant, &c., with periodic optical inspection of the tooth profile and surface.

Automation.—Turning from machine elements to the complete system, a series of investigations has been undertaken in the errors involved in turning copying systems, both continuous hydraulic and discontinuous electro-hydraulic, considering them both theoretically and in practice. Also connected with the problem of automatic control of machine tools is slide friction, particularly at very low speeds, when "stick-slip" occurs. A series of experiments to investigate general frictional properties includes variation of rubbing speed, surface materials and finish, normal pressure, and lubrication; a hydraulically actuated table moves reciprocally at a steady controlled rubbing speed under a loaded pad and the effective coefficient of friction is estimated from electrical measurement of the tangential force.

Cutting Tools.—A range of dynamometers measuring cutting forces in three directions is produced in the department for industrial use; these employ inductive measuring elements and the associated electrical equipment. In the department itself tests are run to find the variation of the static cutting force with cutting velocity, cutting angles, and materials, &c. Tool wear tests investigate the tool bit life as a function of similar variables, with periodic measurements of flank wear, rake surface cratering and other visible features; criteria of wear are thus derived for new cutting materials, such as ceramics. Concurrent with such long term wear testing, techniques for a short term estimation have been developed using radioactive bits; having chosen a suitably retentive material, tests are run with two diametrically opposed tools, one activated and the other not, and the wear on rake and relief faces thus determined separately by examination of the chip.

Spark Machining.—The problems of spark machining and "grinding" are considered both generally and for specific applications. The influence of spark energies and subsequently machining rates on the metallurgical properties of the surface crust has been investigated with the interdependence of the surface finish; also the mechanical problems of feed control by a variety of methods, and the increased scope of machine design resulting from the absence of cutting forces. Die clearances and materials have been optimised for specific problems and flushing techniques developed.

Publications

The appended bibliography amplifies this description of the department's work, and also demonstrates the importance that is attached to publication of results. The Institute prepares each month one complete issue of the weekly engineering journal *Industrie-Anzeiger* and is thus able to publish its findings with the minimum of delay; this quick and widespread publication is in keeping with the underlying theme of service to the machine tool industry as a whole.

Acknowledgments

The author wishes to thank Professor Opitz and his staff for their hospitality and endeavour in making the most of a short visit; and the Staveley Research Department of Bedford for their sponsorship.

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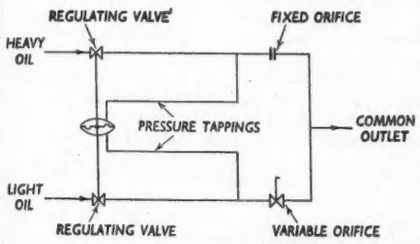
British Gear Manufacturers' Association

On Tuesday, May 10, the British Gear Manufacturers' Association held a meeting at the Piccadilly Hotel in London. The members suffered a disappointment in that Dr. Genkin, senior scientific officer of the Machinery Institute of the Soviet Academy of Sciences who was to have presented a paper on the "Development ot Novikov Gearing in the U.S.S.R.," was unable to be present. In his absence a general discussion of Novikov gearing took place. Following the meeting a luncheon was held. After the loyal toast had been honoured the chairman, Mr. R. B. Stone, presented the Association's Gold Medal to Mr. Arthur Sykes. It was the first occasion on which this medal has been awarded. Its recipients are not to be confined to members of the Association, nor even to members of the British industry. The chairman thought it particularly appropriate that the first medal should go to Mr. Sykes. He had played a generous part in the work of the Association, and he had spent over fifty years in the gear industry. He was the author of books on gearing, and had presented many papers to learned societies. Since 1929 he had served on the British Standard Committee for gears of which he had been chairman since 1940. He was the doyen of the British gear industry.

Blending of Fuel Oils at Ellesmere Port

In order to supply fuel oils to within closely specified limits the Mobil Oil Company, Ltd., has installed blending units at its Ellesmere Port terminal. This equipment, in association with a special viscosity controller, means that a fuel can be blended to within ±1 per cent of specification. The method of in-line blending also reduces the tankage required and effects other economies.

UNTIL comparatively recently the majority of fuel oils were batch blended and held in storage tanks against delivery. However, although for marine purposes the fuels required were in the main defined as gas oil, Bunker C and diesel oil, the grades of fuel required for industry were defined by viscosity. Although these largely consisted of 200 seconds, 900 seconds and Bunker C at about 3500 seconds Redwood No. 1, nevertheless, there was a demand for a considerable quantity of graded oils to meet



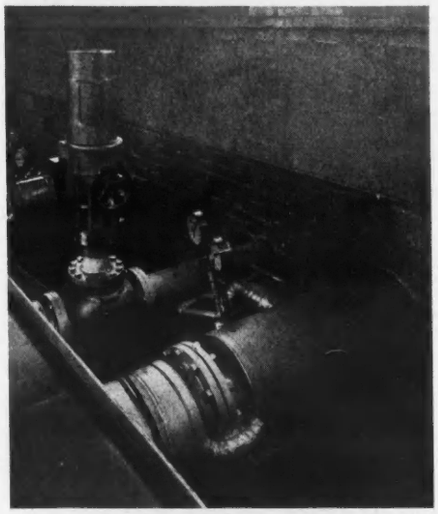
Diagrammatic arrangement of blending unit

the specifications of many public authorities, individual manufacturers and shipping companies. Thus, the range of fuels to be held meant a considerable capital investment in oil tanks which represented a major portion of the capital required for product marketing. The introduction of the in-line blending system has resulted in a reduction of the overall tankage required and a matching reduction of capital required per ton of storage, coupled with the advantage of now only requiring the delivery of two grades of oil to the oil terminal and in larger consignments.

Blends using two base stock oils fall within the range defined by light fuel oil and heavy fuel oil, while the viscosity may have a variation of as much as 100 seconds Redwood No. 1. Although such a wide margin is commercial practice for in-line blended fuels, the Mobil Oil Company, Ltd., thought that it would be of advantage to the buyer if the product could be produced continuously at a viscosity having a much closer limit of variation of about ±2 per cent. Furthermore, if the fuel required could be produced close to the upper limit of viscosity then there would be a saving on the amount of expensive gas oil blend stock. Schemes to achieve blending to closer limits were developed by the company's engineers and with the co-operation of the Fisher Governor Company, Ltd., a member company of Elliott-Automation, Ltd., and Smith's Industrial Instrument Division, were given practical shape. The results of the combined effort have been incorporated in the Ellesmere Port Terminal of the Mobil Oil Company, Ltd., and fuel oils are now being blended to buyers' specifications within a very small margin of the viscosity required.

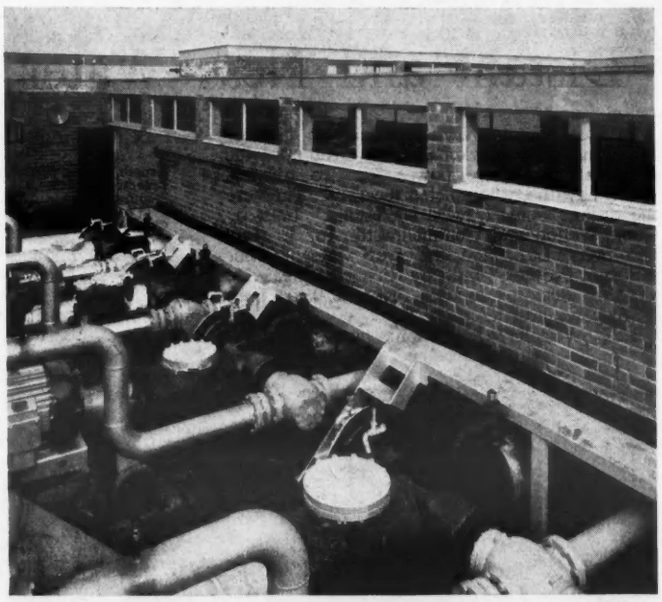
It was some years ago that the Fisher Governor Company, of America, developed a unit to give any desired ratio of blend. This unit incorporated the principle of maintaining a constant pressure drop across two orifices the areas of which could be varied as required. Subsequent developments by the Fisher Governor Company, Ltd., have enabled the unit to handle high viscosity oils up to 5000 seconds Redwood No. 1 and it blends together in predetermined volumetric proportions a high viscosity with a low viscosity fuel to produce oil of an intermediate viscosity. The equipment, shown (left) in diagrammatic form, employs the principle of parallel metering of two fluid components and establishes equal pressures at the point of metering. To compensate for the rapid change of viscosity with temperature of heavy fuel, this component is metered through a fixed orifice which has an edge contour such that the discharge coefficient is fairly constant despite fluctuations in viscosity. A variable orifice in the form of a valve of sleeve and piston design meters the light oil. This valve can be seen in the diagram which shows the light oil and heavy oil lines of the blender.

The pressure balancing unit consists of two pressure regulating valves actuated by a common diaphragm to either side of which are lead tappings taken from just upstream of the fixed orifice and the metering valve. Our illustration (right) shows the four sets of supply lines to the blenders, and the balancing diaphragm and inlet valves. Pressure difference between the two metering points results in a compensating movement of the common valve stem such that the pressure losses of the two streams are adjusted until equal pressure is obtained by raising the lower and reducing the higher. Thus, accuracy of blend can be achieved without an external source of power or the need for accurate pump pressure settings. The blend ratio is directly proportional to the areas across the metering devices and since one is a fixed orifice, the ratio is a function of the travel of the metering valve in the light fuel line. Each of the four blending units installed at the Ellesmere Port terminal has heavy and light oil component arms of 10in and 6in diameter respectively and a 12in diameter outlet. The pipes are lagged and steam traced and, to ensure homogeneity of blend, an "Impellator" mixer is fitted before the measuring point of the controller.

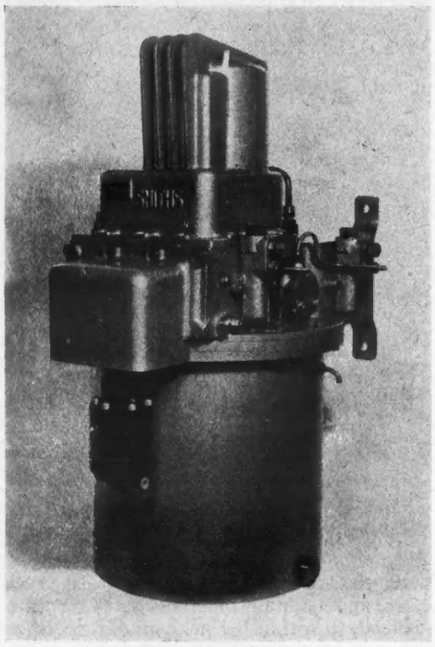


Metering valves in light oil line of blending unit

Since the distributing company wished to ensure and maintain a high degree of accuracy of blend, to within ±1 per cent of a specified viscosity, it was decided to operate the Fisher blending unit in conjunction with a Smiths viscosity controller. The addition of the latter makes the installation self-compensating for viscosity changes of the component fuels. The controller, seen in our illustration, is designed to adjust the setting of the metering valve by means of an electrical signal, so as to correct variation in viscosity outside the prescribed limits. The controller provides continuous precision control of the blending process, so that product viscosities can be guaranteed to within ±1 per cent, and also effects a saving of 3 to 4 per cent in the blending costs. In the unit there are two viscometers and the operation principle is to balance continually the viscosity of a sample from the supply line against the viscosity of a laboratory sample prepared to specification. A rotating cup viscometer measures the viscosity of each sample and the two viscometers run in a warm water bath and are driven at the same speed by an electric motor. The laboratory sample is at



Supply lines to blending units; the balancing diaphragms and inlet valves are also shown



Viscosity controller

the temperature of the bath, while the line sample is passed through a heat exchanger to raise it to bath temperature. When the viscosities of the samples are the same, the balancing arm is in equilibrium, but when they are not the same the difference in the output torques causes the balance arm to move and operate a microswitch and send a signal to amend the setting of the metering valve as indicated.

At the terminal there are fourteen tanks, having a total capacity of 84,000 tons, including three heavy oil tanks each of 13,000 tons capacity and one gas oil tank of the same capacity. Eight electrically-driven Hamworthy vertical positive displacement screw pumps handle the heavy fuel oil and are mounted in line on a concrete base. These pumps operate in pairs, deliver from the storage tanks to a 10in line and are rated to handle 550 gallons per minute of oil, of 2250 seconds Redwood No. 1 viscosity at 120 deg. Fah., with a working pressure of 110 lb per square inch. Each pump is powered by a 70 b.h.p. motor running at 975 r.p.m. and control is fully automatic from the pressurised discharge lines; the opening of a discharge valve at a loading point starts the first pump on the blender in use. When the flow reaches the maximum capacity of the first of the pair of pumps a pressure difference sensing switch, fitted across the fixed orifice, switches on the second black oil pump. Conversely, as the demand decreases and pressure increases, the pumps shut down in sequence.

Sigmund centrifugal pumps provide the light oil component through a 6in diameter line to the blender. As already noted, signals form the viscometer controller adjust the setting of the metering valve, mounted on the light oil line, to vary the size of orifice. This sets up a pressure difference which is passed through the pressure tappings to the diaphragm to operate the pressure balancing valves and equalise the pressure in the component oils. Each blending unit is capable of blending stock to produce oils of viscosities ranging from 200 to 1500 seconds Redwood No. 1 in proportions of 97 to 3, to 60 to 40 at flow rates up to 1400 imperial gallons per minute to within an accuracy of ± 1 per cent of the specified viscosity.

Distant and Near Water Trawlers

DIESEL engines manufactured by member firms of the Hawker Siddeley Group provide the main propulsive power for two trawlers which have been completed recently. They are the distant water trawler "Westella," built by Cook, Welton and Gemmell, Ltd., for J. Marr and Sons, Ltd., and the near water trawler "Boston Provost," built by Richard Ironworks, Ltd., for Boston Deep Sea Fisheries, Ltd., both of which we illustrate.

The "Westella" has a tank tested hull form and the following main particulars:

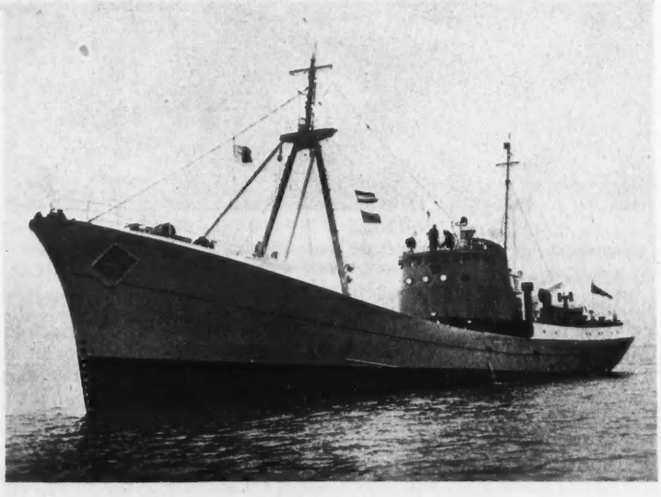
Length between perpendiculars ...	185ft
Breadth moulded	33ft 6in
Depth moulded	16ft 9in
Fish room capacity...	18,170 cubic feet
Complement	30

The accommodation consists of two four- and two six-berth cabins for seamen on the cabin flat, cabins for boatswain, cook, second and third engineers, chief engineer, and mate in the deck house on the main deck, while the captain has a suite on the lower bridge deck, where there is also a cabin for the radio officer.

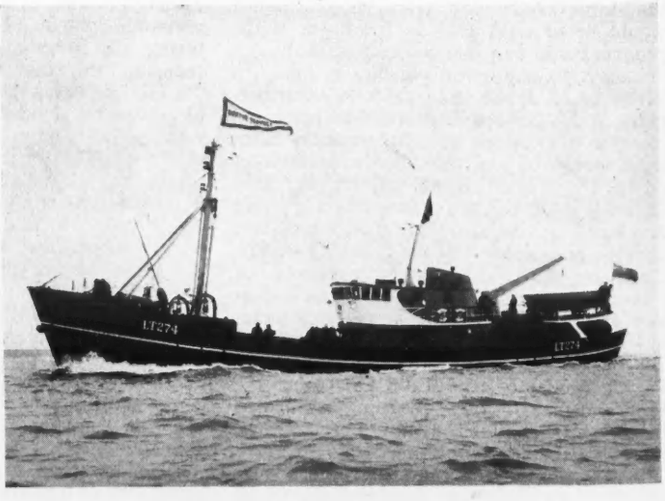
The Holmes "Lektron" trawl winch is driven by a 300 h.p. motor and has two barrels, each having a capacity for 1500 fathoms of 3½in "G.B.T." high tensile trawl warp, manufactured by British Ropes, Ltd. Power for the winch is provided by a 240kW Laurence Scott Ward-Leonard generator driven at 600 r.p.m. by a Mirrlees mark JLSA.5, five-cylinder, 452 b.h.p. diesel engine. The trawl winch operates the port anchor while the starboard anchor is operated by a Gemmell and Frow electric windlass. The ship is fully equipped with navigational aids and carries an 18ft wooden working boat, under a Schat single-arm centre-line mechanical davit, and four twelve-person inflatable life rafts. About 200 tons of diesel oil fuel are carried in wing tanks and the double bottom in way of the generator room and wing tanks forward.

Main propulsion is by a Mirrlees "Monarch" class A.L.S.D.M. turbo-charged six-cylinder, four stroke, direct injection diesel engine similar to that described in the September 11, 1959, issue of THE ENGINEER. The engine has a bore of 19in by 27in stroke, giving a swept volume of 7655 cubic inches, and is rated to develop 1800 s.h.p. continuously at 225 r.p.m., corresponding to a brake mean effective pressure of 138 lb per square inch. A general view of the main engine is illustrated opposite. Three levers control the engine, one is for stop, start and run; a second controls engine speed and a third provides ahead-astern manœuvring. Lubricating oil supplies, fresh water and salt water circulation are provided by separate motor-driven pumps. This engine, which is of cast iron construction, has been developed to ensure reliability with maximum availability, long periods between overhauls and ease of accessibility for maintenance purposes. Inspection doors permit the removal of pistons and connecting rods and there is a specially designed kit of lifting appliances and tools to aid the rapid dismantling of the engine, and removal and refit times respectively range from about ten minutes for a cylinder liner to fifty minutes for a cylinder head. The engine is directly coupled to a "Nikalium" propeller having a diameter of 9ft 3in by 7ft 7in mean pitch.

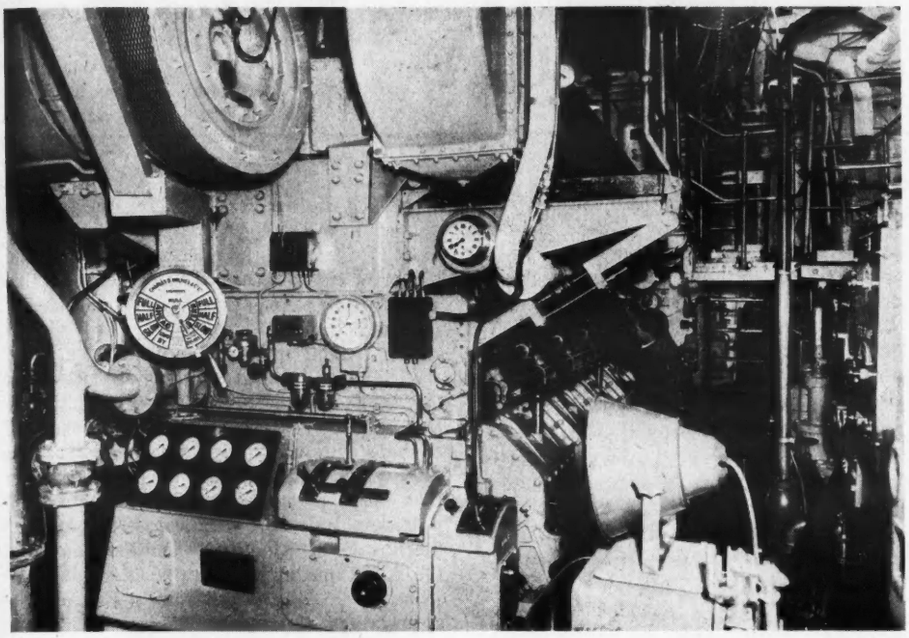
Hamworthy water circulation, lubricating oil, bilge, general service and oil fuel transfer pumps are mounted in the engine-room, as are Alfa-Laval purifiers, and an oil-fired steam boiler and a deck water service heater supplied by Charles D. Holmes and Co., Ltd. To port is a Russell Newbery 40kW auxiliary set with air compressor and a motor-driven air compressor. Power for electric lighting and for auxiliaries is supplied by two 105kW, 220V David McClure generators, mounted to port and starboard of the winch power unit, each driven by a Mirrlees mark TLA3 three-cylinder direct injection diesel engine developing 157 b.h.p. at 600 r.p.m. Arrangements have been made for one of these generators



Distant water trawler "Westella"



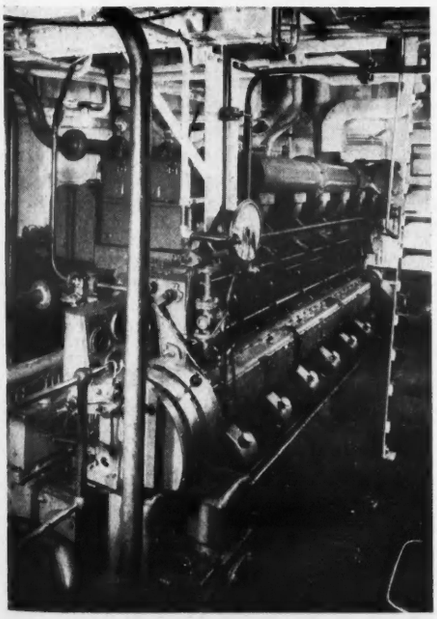
Near water trawler "Boston Provost"



Control end of the six-cylinder "Monarch" engine in "Westella"

to power the trawl winch when working on light load. To assist in the maintenance of the main and auxiliary diesel engines and to ensure the maximum availability a Mirrlees depot has been established at St. Andrews Dock, Hull, and manned by personnel on twenty-four-hour call.

The smaller of the two vessels, the near water trawler "Boston Provost," is one of a class of trawlers of special design as approved by the N.P.L. and has the following dimensions: length overall 116ft 3in, length between perpendiculars 104ft, breadth moulded 23ft, and depth moulded 11ft. These ships usually remain at sea for about eleven days and there is accommodation for a crew of thirteen, consisting of a cabin on the bridge deck for the captain, an engineer's cabin at the forward end of the house on the main deck and on the cabin flat aft a cabin for the mate, together with three two-berth and one four-berth cabins. Heating is by hot water radiators. A Mono-line single-arm centre-line davit handles the 16ft long wooden lifeboat and in addition there is an inflatable life raft.



National "Sovereign" six-cylinder engine in "Boston Provost"

Gear is fitted for trawling on both port and starboard sides and the fish room has a capacity of 5040 cubic feet and space for 25 tons of ice. The trawl winch, which is pneumatically controlled, is driven by a flat belt from a power take-off at the forward end of the main engine, and the two cast steel barrels each hold 550 fathoms of 2¾in warp. Finger-tip control of the winch is achieved by an air operated jockey pulley and brake system.

In the spacious wheel house are mounted Decca navigation and plotter display units as well as Marconi Fishgraph and Graphetti dry paper recording echometers. Steering is by Vickers-Armstrongs hand hydraulic gear. The foremast is of tripod construction and carries a landing derrick and on the forecastle is a Gemmell and Frow hand windlass.

For propulsion purposes, the ship is fitted with a National "Sovereign" six-cylinder turbo-charged direct reversing diesel engine fitted with an intercooler, and shown in our illustration. It develops 515 s.h.p. at 300 r.p.m. and is coupled through a Wigglesworth clutch to a "Novoston" solid four-bladed propeller having a diameter of 6ft by 4ft 1½in pitch and a developed blade area of 15 square feet. This class of engine was described in THE ENGINEER on September 25, 1959, and is built by the National Gas and Oil Engine Company, Ltd., the bore and stroke being 12in and 15in respectively, and the brake mean effective pressure 130 lb per square inch. As with the "Monarch" engine, particular attention has been paid in the design to simplifying maintenance operations, thirty-five minutes being required to remove the piston and connecting rod through a crankcase door. Extremely simple engine controls and reversing mechanism and the change over from full ahead to full astern can be achieved in about ten seconds without detrimental effect on the engine or its performance. To ensure that the engine requires the minimum of maintenance, scantlings are robust and the main constructional parts are of cast iron and the engine, which has a length of 22ft from thrust shaft to forward power take-off coupling, a width of 5ft 10in and a height of 9ft 2in, weighs 25 tons.

The power take-off extension shaft is 7ft 6in long and from it a 14in wide flat belt drives the trawl winch on deck, a vee-belt drives a 15kW variable speed generator, and other belt drives provide power for a Hamworthy fresh water circulating pump for the engine cooling system and a Hamworthy air compressor. For harbour use and to supplement the main generator, is a 15kW generator powered by a 27 b.h.p. Russell Newbery diesel engine. Clutch coupled to the set is a Hamworthy air compressor and a Gilkes 250 general service pump. The latter is used for bilge, circulating, wash deck and fire-fighting duties. For heating and domestic purposes there is an oil-fired boiler and there is storage for 14·5 tons of fresh water for all purposes, together with 33 tons of diesel oil fuel in two wing bunkers in the engine-room. Full service facilities have been arranged at a number of ports so as to ensure the ready supply of spares and the maximum availability of the engine.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GENERAL REQUIREMENTS FOR AIRCRAFT ELECTRICAL EQUIPMENTS

No. 2G.100: Part 3: 1960. Price 6s. B.S. G100 dealing with general requirements for aircraft electrical equipments is being revised to take account of the requirements of modern high-performance aircraft operation, and in the light of experience of working to the provisions of the first edition, which was published in 1952. The revised standard will be of the highest importance to the aircraft industry, as it provides the basis of approval by the Air Registration Board of electrical and other equipment for civil aircraft.

Part 3 of the revision ("Characteristics of Electrical Power Systems and Equipment") has been completed, and, at the request of the aircraft industry, published in advance of other parts of the new standard, which are still in course of preparation. The complete revised standard will consist of the following parts (other parts may be prepared as required) which will be issued separately: Part 1: "Declarations, Identification and Construction"; Part 2: "Environmental and Operating Conditions"; Part 3: "Characteristics of Electrical Power Systems and Equipment"; Part 4: "Instruments and Indicators"; Part 5: "Rotating Electrical Machines."

It is not intended that the new standard should be applied retrospectively. Existing equipment will remain in use for some time, and the matching of new equipment with old systems (and vice versa) will need consideration.

Part 3 defines the nominal characteristics of aircraft a.c. and d.c. electrical systems. For a.c. installations the system shall be 200V, 400 c/s star-connected, three-phase, four-wire. The neutral point of each power source shall be connected to the aircraft structure, which shall normally constitute the fourth wire. When load is switched from 75 per cent to 25 per cent of nominal full-load capacity, the transient disturbance of frequency shall not exceed 50 c/s and these limits shall also apply when the speed or power of the prime mover is varied at the maximum rate necessary for operation of the aircraft. The disturbance shall decay at such a rate that after 250 milliseconds the frequency is within the steady state tolerance (380-420 c/s) and shall be completely damped out within a further one second. Permissible transient voltage disturbances in the same conditions of switching are illustrated graphically. When loads in normal use are switched, the transient disturbance of voltage shall be such that the product of maximum deviation (in volts) from the steady state value (195-205V r.m.s.), and the period in milliseconds after which the voltage remains within steady state limits, does not exceed 3000, with a maximum limit on deviation of 60V and on duration of 150 milliseconds.

The d.c. supply systems shall be single-wire, earthed negative, nominal 28V. Under steady state conditions the line voltage shall be within the limits 27·0V and 28·5V but it is noted that where d.c. is obtained from a primary a.c. system the voltage may vary beyond these limits provided the range at the utilisation equipment is not greater than specified under "operating voltages."

Normally the cables for continuously-operating equipment shall be selected so that the difference between the busbar voltage and that at the equipment terminals does not exceed 3·5V on 28V d.c. systems and 10V on 200V a.c. systems. Utilisation equipment for 28V d.c. systems (other than that used for engine starting) which is required to run off a discharging accumulator shall be designed generally for 18V to 28·5V and in the case of contactor coils for 16V to 28·5V.

An appendix gives a suggested a.c. load for design and test purposes which is considered to a large extent representative of mixed loading in service.

Copies of drafts of Parts 1 and 2 of this standard have already been circulated, and it is hoped to obtain as many comments from industry as possible on this new standard.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

VECTOR DIMENSIONAL ANALYSIS

SIR,—The possibility of considering that space co-ordinates each have corresponding separate space dimensions was recognised in the last century, yet misapplications of this idea are still published. It is hoped that the following will help to clarify the use of this method. The mathematical criterion for an analysis is given by the well-known Pi Theorem, with a further condition that the number of dimensionless groups indicated by the Pi Theorem should not be less than one. Whilst this mathematical criterion is a necessary condition for valid analysis, it is not a sufficient one : it is necessary also that the quantities chosen for the analysis are correct and sufficient to represent the problem under study.

The application of the mathematical criterion can be made clear with the aid of an example. It is known by ordinary dimensional analysis, where all space dimensions are accorded the same dimensional connotation, that to describe drag in incompressible laminar flow two dimensionless groups arise :

$$C_f = f(Re)$$

If, now, each orthogonal space co-ordinate is considered to have a distinct dimension associated with it, the net number of dimensions is increased by two, and since the new space dimensions pass the test of independent appearance, the number of corresponding dimensionless groups would be zero. This fails to satisfy the mathematical criterion mentioned above. In order to comply with that criterion, it is permissible to distinguish only one particular space dimension from the other two. At first this asymmetry may appear puzzling, and there is further the question of which dimension is to be distinguished from the other two possible ones. However, the puzzle is rapidly resolved when use is made of the boundary layer assumption, which can be given a dimensional interpretation. This assumption can be stated in the form that in a fluid layer close to the solid surface of a body the velocity gradient along the normal to the surface is very large. The direction of the resultant shear force on the surface is frequently unknown without detailed mathematical solution (for example, the direction of the resultant shear force on an isolated rotating disc is not the same as the direction of rotation), so that the directions in the plane of the surface cannot be distinguished. The direction normal to the surface can be distinguished from those in the surface, however, and this distinction will affect the dimensions ascribed to the quantity viscosity, which has the form of force—per unit area—per unit velocity gradient. The gradient will be along the normal to the surface. Here another form of the boundary layer assumption can be noted : that viscous forces act predominantly in the direction parallel to the surface of the body. If, for convenience, orthogonal curvilinear co-ordinates are employed, with x and y (dimensions L) co-ordinates lying in the body surface and z (dimension Z) being normal to it, it is possible to write for viscosity and density

$$\mu = \left[\frac{F}{L^2} \cdot \frac{TZ}{L}\right] ; \quad \rho = \left[\frac{M}{L^2 Z}\right].$$

It is then found that for laminar boundary layer flows over immersed bodies, where the characteristic length dimension is in the plane of the surface,

$$C_f \cdot \sqrt{Re} = \text{const.}$$

and for laminar enclosed flows, such as pipe flow, where the characteristic length is normal to the wall surface,

$$C_f \cdot Re = \text{const.}$$

These results are, of course, confirmed by exact analysis and by experiment. The method may be extended to the study of convective heat transfer. In this case, a thermal boundary layer assumption may be made ; in a layer close to the surface, the temperature gradient along the normal to the surface is very large. This affects the dimensional connotation which is given to the thermal conductivity, and following this it is found for laminar boundary layer flows that

$$Nu/\sqrt{Re} = f_1(Pr)$$
$$Nu/\sqrt[4]{Gr} = f_2(Pr).$$

The use of distinction between space co-ordinates has been called vector dimensional analysis. The use of the method is not restricted to the cases given above, which are illustrative examples only.

P. D. RICHARDSON

Brown University,
Providence 12,
Rhode Island, U.S.A.,
April 14, 1960.

TWO-SPEED ELECTRIC MOTOR WITH A SINGLE STATOR WINDING

SIR,—I am grateful to you for drawing my attention to the article in your issue of May 6 about the new class of two-speed squirrel-cage induction motor which has been invented and developed in these laboratories. These motors use the principle of pole-amplitude modulation ; and, after the success of small motors built in these laboratories, they have been taken up by several industrial companies, including Associated Electrical Industries, Ltd.

May I be allowed to make a few comments?

The original I.E.E. paper on this subject (by Rawcliffe, Burbidge and Fong) mentioned in your issue, is now almost obsolete. One 70/35 h.p. motor, for eight/ten poles, was built to this design by A.E.I. (Manchester) ; but, since then, the principle has been greatly extended in range, and much improved in application. In due course, further papers will be offered to the Institution of Electrical Engineers, describing the various stages in the development of this invention. Much progress is still being made.

It is stated that the A.E.I. Heavy Plant Division has evolved an alternative to pole-amplitude modulation " by using fractional-slot windings," the alternative being thought to have various relative advantages, at the price of certain disadvantages. However that may be, it must not be thought that pole-amplitude modulation does not involve fractional-slot windings. On the contrary, the A.E.I. machine illustrated in your issue, wound to a design drawn up in Bristol, has a fractional-slot winding, for ten poles. When the pole-number is changed to eight poles, it happens that the winding becomes an integral-slot one, *taking an average*. It is, however, very doubtful whether a winding with non-uniform coil-grouping can be truly described as an integral-slot winding, even when the *average* number of slots per pole per phase is integral. In Bristol, we prefer to describe such a winding as a quasi-fractional-slot winding.

By its very nature, a single three-phase winding which can produce, alternatively, either of two pole-numbers can only be an integral-slot winding for both speeds when the number of slots is three times the least common multiple of the two pole-numbers. For all other slot-numbers except this, these machines will be fractional-slot machines, for either or both speeds. A great variety of slot-numbers can be, and have been, successfully used for these machines, which thus, in general, have fractional-slot windings.

A digital computer is certainly a great help in doing repetitive calculations, of the same type, for a series of designs involving different slot-numbers, once a design is broadly settled. On the other hand, a normal mathematical analysis in algebraic terms is often of much greater value in the early stages of a basically new type of design ; because—to an informed mathematical mind—the controlling factors in the situation are much clearer in algebraic than in arithmetic terms.

It ought perhaps to be added that, with the consent of this University, the patent rights in relation to pole-amplitude modulation have been assigned to the National Research Development Corporation.

G. H. RAWCLIFFE

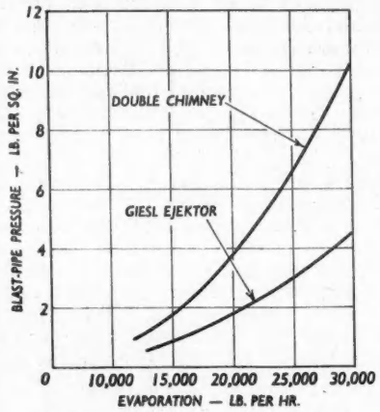
Professor of Electrical Engineering,
University Engineering Laboratories,
Bristol, 8,
May 11, 1960.

LOCOMOTIVE COAL TRIALS

SIR,—It is pleasant to see that current popular trends have not entirely extinguished interest in the development of our steam locomotives, and I read E. C. Poultney's recent survey of British Railways' tests of

low-grade fuel with interest (March 18 issue). I was sorry, however, not to see reference made to an even more recent series of tests, conducted at the Rugby testing station, in which a double blast pipe and chimney front end was directly compared to a Giesl Ejektor front end, with special reference to the burning of low-grade fuel.

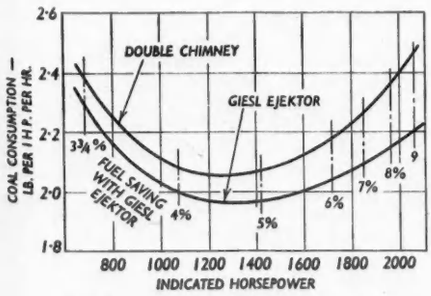
The claims made for the Ejektor are that



Blast-pipe pressure for equal smokebox vacuums

it can maintain a given draught with a back-pressure of less than half that required with the best designs of conventional blast pipe and chimney. Conversely, it can provide the enhanced draughts shown to be necessary for burning the poorer grades of coal without requiring back pressures higher than have hitherto been usual, and without a great reduction in the maximum steaming capacity of the engine.

These claims were substantiated at Rugby, as the attached curves show, and are supported by the Czechoslovak Railways recent decision to fit 1000 of their existing steam engines with Ejektors in preference to the



Specific coal consumption at 50 m.p.h.
Blidworth grade 2B coal

double Kylchap exhaust arrangement with which their modern steam power has been fitted up to the present, and which has for many years been considered the most efficient locomotive exhaust arrangement available.

A. C. STERNDALE

London, N.W.11,
May 12, 1960.

SEEING IT IN THE ROUND

SIR,—
On April twenty-two this year
The Editor of THE ENGINEER
Saw " in the round,"
At top of page two, stating that
To see things only " in the flat "
Was most unsound.

He first of all referred to roads,
Particularly their human loads :
I take him up on this.
For one-way traffic " in the round "
From which no egress can be found
Is far from bliss.

For instance ; let him drive to " Brum "
And enter that appalling scrum
Of circuits closed.
He'll see things " in the round " all right,
Be driving round and round all night
'Til cyanosed.

" Universal Observer " doesn't scan,
But he's the only one who can
See " in the round."
I think it not unfair to mention
That toying with the fourth dimension
Is most unsound.

One who coins these curious phrases
Must face the problems that he raises
Of science diction.
THE ENGINEER, may I suggest,
Is not the place wherein to jest
With science fiction.

L. C. WOOD

London, E.C.4,
May 11, 1960.

[What we have to put up with !—ED., THE E.]

THEORY OF MACHINES

SIR,—I have read with interest the correspondence following my article, " Theory of Machines," which you kindly published in your issue of March 25. It has been gratifying to observe the measure of support for the changes made in the last few years in the Mechanical Engineering Degree course at Southampton. That similar changes of emphasis have been made elsewhere is an indication that the subject as accepted for the last half-century needed some overhaul and of the awareness, in centres of more advanced learning, of the necessity of keeping abreast of developments and at the same time giving prominence to principles rather than to specific items of machinery.

The letters of Messrs. Matthew and Coull (April 8, 1960) and Mr. Swanson (April 15, 1960) both raise the question of the title of a revised course. The former correspondents say " Theory of Machines is not now an adequate description," and the latter, " we have kept the title because we think that this is the Theory of Machines which matters." Thus it is seen to be a question of what is conveyed by a title. To most engineers of the present time the title connotes that collection of topics described in my article and, as such, is unsuitable for a course which has been drastically changed. Even if all teachers adopted a new meaning to an old title forthwith, it would take a long time before it carried that meaning generally. For that reason it seems that a new title is required to indicate a major change in the subject matter. It has, however, to be admitted that there is difficulty in finding a current word, or combination of words, sufficiently distinctive and self-explanatory to be generally acceptable. We use the title " Mechanisms " but it is not ideal.

Mr. Denton refers to Higher National Certificate courses and his comments confirm an impression of the inadequate nature of some of these courses. Is it not, in the long run, a disservice to the profession for any teacher to give his students a " packaged theory " merely to help him " complete his homework questions " ? It seems far better, and I speak with some years of experience in teaching H.N.C. courses, to try and give the student an understanding of the general principles of the subject rather than " packaged theory."

In conclusion, I support the plea of Messrs. Matthew and Coull for a more mature attack on the kinematics and synthesis of mechanisms on, say, the lines of K. H. Hunt's book. Nevertheless, it will be difficult to find time for it in an undergraduate course.

C. H. HELMER

Southampton,
May 6, 1960.

Book Reviews

Leichtmetall-Versteifungsträger für Hängesteg. By K. SUTTER and A. M. MACKIE. No. 20 in the *TR* Special Series. Verlag Technische Rundschau, Hallwag, Berne, Nordring 4. Price S.Fr.3.20.

ALUMINIUM as a material for civil engineering structures is a comparatively recent development. In Alpnach, Switzerland, there arose in 1956 the need to replace two small wooden bridges by new structures, and in view of the fact that wood had not proved very durable, it was decided to use metal. The bridges have spans, respectively, of about 35m and 20m, and are for pedestrians and cattle. Each comprises a light alloy braced girder deck suspended from steel cables. The publication gives an account of the design and the components, together with a complete set of design calculations. Manufacture and erection are fully described.

Massivumformung. By H. MEYER and W. BIEDERSTEDT. No. 21 of the *TR* Special Series. Verlag Technische Rundschau, Hall wag, Berne, Nordring 4. Price S.Fr.4.20.

EFFICIENT mass production pre-supposes a design which is not only functionally correct but pays due attention to the method of manufacture. The making of a wide range of modern goods involves cutting as well as non-cutting processes. The latter class includes those cases where the shape of the material is changed by plastic deformation. In order to give designers an up-to-date synoptic view of industrial practices the Technical University of Hanover last spring organised an exhibition which the *VDI* later took over and presented in a number of other German cities. The present book is based on this exhibition.

Both the manner of treatment and the wide range of examples quoted will recommend it alike to production engineers, designers, and engineering students.

Books Received

Mechanical World Year Book, 1960. Emmott and Co., Ltd., 31, King Street West, Manchester, 3. Price 5s.

Atomkraft. By Friedrich Munzinger. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, W. Germany. Price DM.42.

The Transactions of the Newcomen Society. Vol. XXX, 1955-56 and 1956-57. W. Heffer and Sons, Ltd., 4-5, Petty Cury, Cambridge. Price 50s.

National Institute of Agricultural Engineering

The National Institute of Agricultural Engineering is a state-aided body which engages in research and development work in the interests of mechanised agriculture. It also conducts impartial tests on tractors and farm machinery and is a centre for information on all aspects of agricultural engineering.

LAST week, the National Institute of Agricultural Engineering held its " open days." These open days are a biennial event which give many people from this country and overseas an opportunity to study the progress of the varied programme of research, development and testing work in agricultural and horticultural engineering which is carried on at the Institute's headquarters at Silsoe, Bedfordshire. Mr. W. H. Cashmore is the director of the Institute. Speaking at a luncheon on the first of the open days, he referred to the need for improved efficiency in agricultural production and emphasised that that improvement depended to a very large extent upon good engineering. The design and construction of new machines for agriculture and horticulture, Mr. Cashmore added, was not enough. In all the work undertaken by the Institute, such essential factors as the best utilisation of power and " making the machine good enough for the job " had to be kept in mind.

Progress in agricultural mechanisation is increasingly dependent on relevant basic data and an important part of the Institute's work is the collection of information needed by designers and those planning new farming techniques. For one of the functions of agricultural engineering is to evolve new farming techniques and, if necessary, to make the case for new and improved equipment to operate those techniques. The Institute's part in this function includes the making of surveys to obtain the background information on existing practice, following that up with laboratory and field investigations.

Mechanical Engineering Department

We began our tour in the mechanical engineering department, which, in addition to testing, research and development work, is responsible for the development of special equipment for use throughout the Institute and at other establishments. During the past year, for example, the department has done further work on mobile weighbridges, the tractor " treadmill " and the tractor test recorder. A 100,000 lb drawbar dynamometer* has been designed and manufactured commercially and the long-term investigations of hydrostatic transmissions and slow-speed potato harvesting are continuing. Furthermore, an analogue computer is now being built for the department to assist the study of tractor kinematics. The Institute's latest annual report, which has just been published, says " now that the arrangements for testing tractors at high temperatures and under dusty conditions are working satisfactorily and a technique exists for running simulated altitude tests, consideration is being given to the provision of a cold room." In the design of the cold room, it is proposed to incorporate input and output mechanical drives passing through the insulating walls. If this arrangement proves successful, it will enable tests of transmissions to be made at low temperatures. Such facilities, it is thought, may prove very useful, particularly in the further development of hydrostatic transmissions.

Other work in progress in the mechanical engineering department includes the development of a tractor front-mounted herbage plot harvester for Rothamsted experimental station ; a small combine harvester for cereal plots, for the Plant Breeding Institute, and a pea viner for harvesting experimental plots, for the Ministry of Agriculture.

Agricultural Testing Department

One of the investigations in progress in the agricultural testing department is concerned with the wear of implements in the soil. In order to assist in the selection and treatment of materials for specified duties, an attempt is being made to gain a more precise knowledge of the behaviour of metals under abrasion in soil. Simplified test implements have been developed, employing thin rectangular plates as edge - cutting elements. By this means, it has been found possible to eliminate large errors due to varying structure in the metal within individual test components and differences in their shape as wear proceeds. Field trials with annealed and cold-rolled copper and mild steel have indicated the importance of work-hardening occurring at the abraded surface and a difference in the relative wear resistance of the metals in sandy and in flinty soils. For the open days, an exhibit was arranged comprising the rotary cultivator and the tool-bar-mounted tine used as test implements, as well as examples of the worn specimens and a jig for measuring wear.

Grain Department

The grain department at Silsoe carries out research and development work on problems arising from the drying, cleaning, handling and storage of cereal grains and other seeds. This work includes the design of various instruments and laboratory apparatus.

One such piece of apparatus for crop drying, which was shown last week, is a simple heat exchanger using an oil-fired space heater surrounded by a metal casing. The experimental work which has so far been done included runs at fuel flows between three and nine pints an hour and airflows from 2500 to 6500 cubic feet per minute. The data obtained suggest that under the best working conditions an overall thermal efficiency of about 75 per cent can be achieved.

The grain department is also engaged in research and development work on conveying. Exhibits were assembled to demonstrate the work on oscillating conveyor mechanisms and on the performance of auger conveyors. Data for augers inclined to the horizontal, we were informed, is at present lacking. The object of the department's present programme is to fill in some of the gaps in the experimental work already done, and to develop a general theory. Tests have been completed to measure the throughput and power required with a 5½in diameter auger (3ft long), at elevations between horizontal and vertical, using augers of 3in, 6in, and 9in pitch, the auger speeds ranging from 75 to 500 r.p.m. For these tests wheat was used, at a moisture content of 13 to 14 per cent and bulk density of 50 lb per cubic foot. The maximum throughput (horizontal) was approximately 1200 cubic feet per hour (27 tons per hour) achieved with both the 6in and 9in pitch augers, at 400 and 500 r.p.m. respectively ; this was not the absolute maximum, but greater throughputs were not possible because of the inability of the circulating conveyors to handle more grain. With the auger vertical, its performance was roughly one-third of that when horizontal. With the 3in pitch auger, however, there was little difference in throughput between horizontal and 60 deg. elevation, while even when vertical its performance was still two-thirds of that when horizontal. The performance of all three augers when vertical was almost identical. In general, the 6in pitch auger was most economical in power required, and the 3in pitch auger least economical. It should be understood that these results apply only to the experimental auger. There is some doubt whether the fall-off in throughput at auger speeds above approximately 200 to 250 r.p.m. is due to the inherent characteristics of the auger itself, or to limitations imposed by the intake hopper. Consequently, some work is being done to investigate this problem ; a radioactive source will be used to determine whether the auger is completely full at all speeds, or whether, due to centrifugal force, the mass of grain is actually hollow at high speeds. It is intended that future work shall include tests with wet grain, and possibly other materials. A rig is also being designed for an attempt to measure the damage to grain caused by augers.

Horticultural Engineering

The open days enabled many visitors to see the extent of the work that is now in progress in the Institute's horticultural engineering department. Some of it is concerned with irrigation and allied problems. One exhibit demonstrated the " tensiostat," which has been developed for the automatic control of water application ; it is now being used in the growing of cucumbers, separately controlling the application of water to the roots and to the leaves.

Problems in spraying for pest and disease control are being investigated, the application of chemicals by aircraft being one of them. A study of spraying by aircraft is being made to measure the influence of aerodynamic factors both on the distribution of chemical on the crop and the resulting biological efficiency. Mechanisation of bulb growing is also being studied. Three machines for planting bulbs have been developed and a machine for lifting bulbs has also been devised. Another interesting study in the horticultural engineering department is that related to the steerage of tractors in rowcrop work. For hoeing and other operations requiring accurate steerage of implements along the rows under the control of one man, the tractor and implement need to be considered as one machine designed to allow the operator to achieve maximum control of its performance. Experiments to determine the optimum transmission for the steering mechanism have been made with a rear-engined " tool carrier " tractor built for the purpose.

* The Engineer, November 27, 1959.

SHORTER REPORTS

Launch of Transatlantic Liner "France"

At the invitation of the Compagnie Generale Transatlantique we were present at Sainte Nazaire on May 11, when the transatlantic liner "France," was safely launched from the slip which she has occupied at the yard of her builders, the Chantiers de l'Atlantique (Penhoët-Loire) since September, 1957, when the keel was laid. This is tne same slip on which the "Normandie" was built and from which she was launched in October, 1932. Following speeches by Monsieur René Fould, the chairman of the builders, and by Monsieur Jean Marie, the chairman of the owners, Madame de Gaulle, the ship's sponsor, named the ship "France," and when preparations on the slip were complete, which included the cutting of two steel anchor plates, cut the ribbons to allow the traditional bottle of champagne to be broken on the bow. With the ship waterborne, the ceremony was concluded by an address by the President, General de Gaulle.

The liner, which is the largest and heaviest ship to be launched from a French yard, has an overall length of 1035ft by 110ft beam and weighed about 33,500 tons at launch. The ship was carried in two ways, each 7ft 10in wide and having a declivity of 1 in 18, and the cradle which weighed approximately 610 tons included a welded steel fore poppet to accommodate the fine lines at the forward end of the ship and strong enough to sustain a load probably amounting to about 8000 tons when the stern lifts. A paraffin-based launching grease was used and able to take bearing pressures up to 3·5 tons per square foot. Each way incorporated three hydraulic launching triggers, one of 250 tons, one of 300 tons, and one of 500 tons, sufficient to sustain a maximum reaction down the ways of 2100 tons. Also in place were a number of knock-out wooden dog shores and, in addition, there were two steel plates welded to the fore poppets and anchored to concrete blocks. It was these plates which were cut, just prior to launching, as a symbolic gesture. Four 100-ton rams were in place at the way ends to ensure that the ship moved at the launching signal.

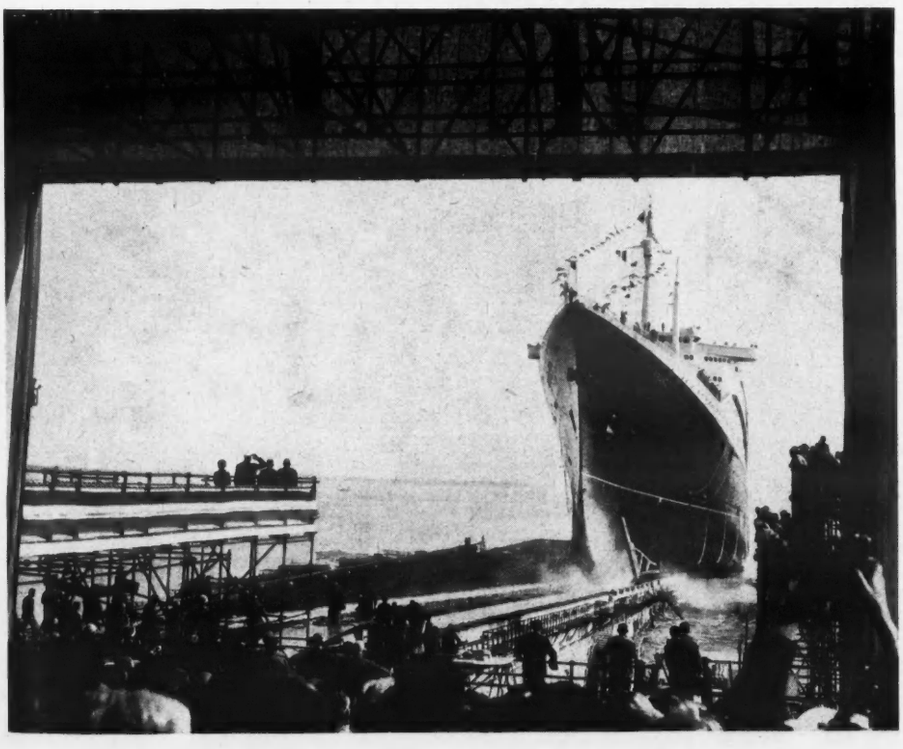
The depth of water available called for certain precautions to prevent the stern attaining too deep a draught before lifting, with possible damage to the stern gear. For this purpose two 300-ton caissons were attached to the aft end of the hull and provided additional buoyancy at the stern, equivalent to an upward thrust of 500 tons, so that the stern lifted earlier. These caissons also acted as brakes and assisted the drag chains to bring the ship to a stop from an initial speed of about 26ft per second when the stern entered the water. One 750kW and two 200kW generators were on board to provide power for the mooring capstans and for lighting.

At launch the structural work was practically complete and both the piping and ventilation services were well forward. Installation of main and auxiliary machinery was well advanced except for aft set of rooms where, for reasons of stern launching draught, it was necessary not to concentrate too much weight. Our illustration shows the liner moving down the ways and the bulbous bow and the fine lines of the ship can be seen.

When in service the ship will carry 500 first-class and 1500 tourist-class passengers with accommodation arranged on a horizontal basis, thus creating the impression of being a one-class ship, with the first-class public rooms on the upper promenade deck and the tourist-class rooms on the promenade deck. The liner, which is expected to have a displacement of about 55,000 tons, will be propelled by four sets of C.E.M.-Parsons four-casing, single reduction geared turbines, each driving four propellers at 162 r.p.m. and developing a total of 152,000 service shaft horsepower, to give the liner a speed of 31 knots. Eight boilers, fitted with economisers, and superheaters supply steam at 925 lb per square inch and 914 deg. Fah. Each turbine unit consists of an h.p., two m.p. and one l.p. turbines, the h.p. turbine having impulse reaction blading and the remainder having reaction blading.

The main and auxiliary machinery is arranged in eight compartments, each about 67ft in length and arranged as follows: auxiliaries and air conditioning plant for forward part of ship; forward boiler room with four boilers; forward engine-room housing two sets of turbines driving the outer shafts, and electrical generators; two auxiliary machinery compartments containing refrigerating plant and two sets of Denny-Brown stabilisers; aft boiler room with four boilers; aft engine space with two sets of turbines driving the inner shafts; and, finally, the aft auxiliary compartment housing generators and aft air conditioning plant. Each line of shafting can be locked up to a speed of 7 knots and with either forward or aft propulsion sets a speed of 23 knots can be attained. In each of the engine-rooms are three 2250kW Alsthom turbo-alternators, representing a total power of 13,500kW, to meet electrical demand. Also in each engine-room are two distillation plants capable of producing 1000 tons of fresh water in twenty-four hours. The propulsion machinery is estimated to weigh 8000 tons, representing a weight of a little more than 110 lb per shaft horsepower, and the fuel consumption is estimated to be 0·57 lb per shaft horsepower per hour.

It is expected that "France" will be ready for trials towards the end of 1961 and will enter the service of the Compagnie Generale Transatlantique early in 1962.



The transatlantic liner "France" moving down the ways at Saint Nazaire

International Chamber of Shipping

Flag discrimination was one of the main matters discussed at the annual meeting of the International Chamber of Shipping, held in London on May 13, and towards combating it, three resolutions were adopted. The first resolution points out that conditions, imposed by governments, which place restrictions on the employment of shipping in fair competition restrict the development of international trade. This results in the uneconomic use of shipping which is detrimental to trader and consumer and has an adverse effect on the cost of living. The resolution calls for all governments to recognise the economic effects of flag discrimination policies and recommends that constituent organisations should ask for remedial action by their governments, such action being directed towards the abolition of flag discrimination.

Number two resolution notes that the establishment of a joint organisation for economic co-operation and development is being discussed, as a successor to the Organisation for European Economic Co-operation, and recommends that shipping policy should form part of general economic policy and that the liberalisation policy for international trade should apply equally to shipping services. Furthermore, any new organisation should include machinery for dealing with shipping questions, comparable with the Maritime Transport Committee of the O.E.E.C., and should also include the shipping provisions of the O.E.E.C. Code of Liberalisation.

Resolution number three recalls that specific conditions regarding the employment of shipping are attached to aid programmes by certain capital exporting countries, and considers that such restrictions not only diminish the value, both political and economic, of the programmes, but set a harmful precedent. Again, these flag restrictions upon the transport of aid cargoes are not consistent with policies directed toward the development of international trade. The resolution recommends that the importance of shipping aid cargoes freely should be impressed upon Governments and that the flag of the ship for the carriage of goods between lending and receiving countries should be decided upon a commercial basis only.

SHORTER REPORTS *(Continued)*

Institution of Water Engineers

THE sixty-fifth summer general meeting of the Institution of Water Engineers has been in progress this week centred upon Newcastle upon Tyne. The meeting ends to-day with visits to Burnhope reservoir and Wearhead filtration plant and to the site of the new Derwent reservoir, which was described quite recently in these columns. The meeting started on Wednesday when the president, Mr. A. G. McLellan, M.I.C.E. (who is manager of the Sunderland and South Shields Water Company), delivered his address. As customarily, the meeting has concentrated its visits and its technical papers regionally in an area where the president's professional responsibilities lie. This year two papers were presented for discussion, namely, "Problems in the Design and Construction of a Large Scheme of Capital Works," by Mr. T. S. R. Winter, M.I.C.E. (new works engineer of the Tees Valley and Cleveland Water Board), and "Recent Developments and Current Practice in a Distribution Department" by Mr. C. A. Serpell, M.I.C.E. (engineer, Sunderland and South Shields Water Company).

The need for a national policy of conservation and development of water resources—a prominent topic to-day—was referred to by the president in the course of his address. He pointed out that in 1921, the Water Power Resources Committee presented a report, the recommendations of which were even more pertinent now than they were forty years ago. One of that committee's recommendations, the president recalled, urged the establishment of a controlling water commission, the process and duties of which would include the compilation of proper records of water resources, the adjustment of conflicting interests in the use of water, the grouping of the watersheds of the country into suitable areas, and consideration of the development of rivers as a whole from source to mouth, from the point of view of all water interests.

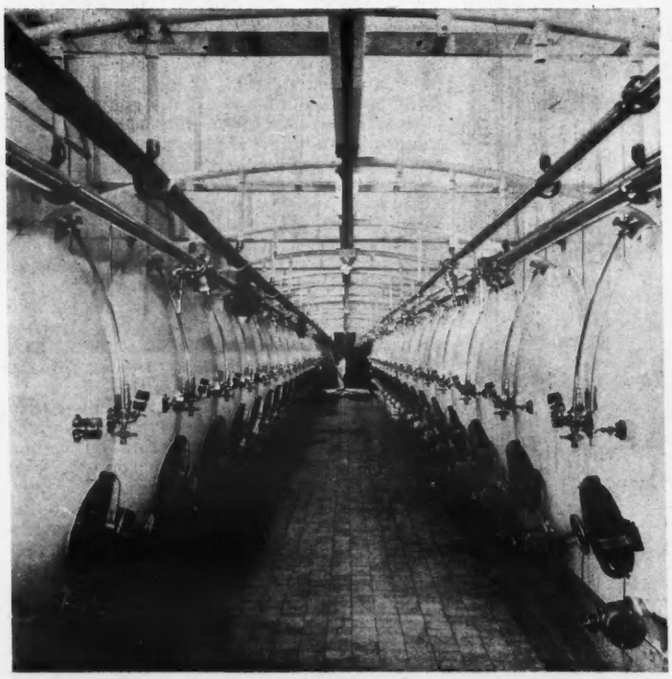
Bottling Plant at Thornton Heath

AT Thornton Heath there has been completed recently for Charringtons, Ltd., a bulk conditioning and bottling plant which has been designed by the company's technical staff, and incorporates the latest improvements, both in equipment and technique for the maturing of Guinness. This is delivered in 3000 gallon capacity road tankers, and is pumped up to the first floor, by Alfa Laval stainless steel centrifugal pumps, where it passes through a plate pattern heat exchanger, and is raised to a temperature of 60 deg. Fah. before being piped to a battery of conditioning tanks. Our illustration shows the conditioning room where there is a total of forty tanks, each of 3000 gallons capacity, the floor between the tanks being paved with acid-resisting tiles laid on a waterproof membrane. The tanks are insulated with glass fibre reinforced with bitumen Prodorglass lined, and fitted with a rouser having a stainless steel propeller.

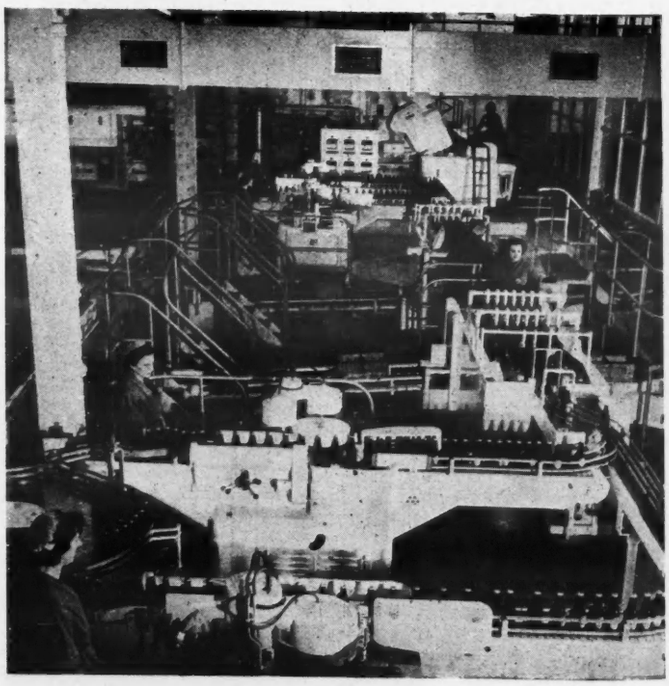
Residence time in the conditioning tank is seven days and, when ready for bottling, filtered air is admitted to the tank at a pressure of about 28 lb per square inch and the stout is piped through chromium-plated copper pipes to the bottling tanks which are also equipped with rousing gear. These are on the same floor and there are five stainless steel tanks, each of 3000 gallons capacity and two smaller tanks, one of 1500 gallons, and the other of 750 gallons capacity. On its way to these tanks the stout passes through a heat exchanger, using brine as a medium, where it is cooled to 32 deg. to 34 deg. Fah. Two J. and E. Hall twin-cylinder ammonia compressors, automatically controlled, in conjunction with a brine system cool the bottling tank cold room and conditioning rooms and chill the stout for bottling. From the bottling tanks the stout flows by gravity into the bottling hall, where there are two bottling lines, one to handle 2000 dozen per hour of nips and half-pint bottles, and the other to handle 1500 dozen per hour of half-pint and pint bottles.

Incoming crates of empty bottles are passed to a Hopkins case unpacker which is capable of eighteen operations per minute, representing the handling of thirty-six dozen bottles per minute. They are passed by conveyor to a Dawson washer where they undergo five washes, including a detergent jet and a final warm rinse. After inspection the bottles are moved to a rotary table and then go forward in single file to be filled and crowned in a machine supplied by Vickers-Armstrongs (Worssam Products), and then after an external wash the bottles are labelled and mechanically assembled for loading into crates. These after being emptied are conveyed to a crate turner and then to a Webster case packer. The loaded crates pass by gravity on a roller conveyor through the floor to the despatch bay. A double-glazed screen encloses the bottling hall and contains the noise and also enables the air conditioning system to operate effectively. Acid resisting tiles are laid on the floor, and have been specially treated in areas where there may be extreme changes of temperature. Beneath the tiling is a glass fibre reinforced membrane and both rear wall and ceiling are covered with a chemically treated vermiculite which prevents condensation and mould growth, as well as providing insulation. A palletiser supplied by W. C. Pantin, Ltd., loads the packed cases on to pallets which are then transferred to the loading bay where they are loaded on to two light alloy platforms, each designed to take a load of 5 tons.

Within the plant battery-driven "Stacatruc" fork lift trucks handle the pallets, and an Alley and MacLellan compressor provides oil free air, while the base exchange water softening plant, of 10,000 to 15,000 gallons per hour capacity, was originally supplied by the Paterson Engineering Company, Ltd. There are two John Thompson boilers which have been converted to oil-firing and are fitted with Todd burners, while the lime soda water softening plant is a product of John Thompson–Kennicott, Ltd. The chimney is aluminium clad so as to maintain the waste gases about dew point and prevent condensation and possible corrosive attack. Other engineering contractors included: George Adlam and Sons, Ltd. (bulk detergent plant); Allen West, Ltd. and Watford Electric and Manufacturing Company, Ltd. (electrical panels); Merryweather and Sons, Ltd. (fire-fighting gear); Morgan Fairest, Ltd. (labellers); Barry-Wehmeller Machinery Company, Ltd. (bottle rotary fillers); and Speediwarm, Ltd. (heating and ventilation). The consulting structural engineers were E. J. Cook and Co. (Engineers), Ltd., and the main building contractors were F. and H. F. Higgs, Ltd.



Conditioning room showing battery of forty 3000-gallon tanks



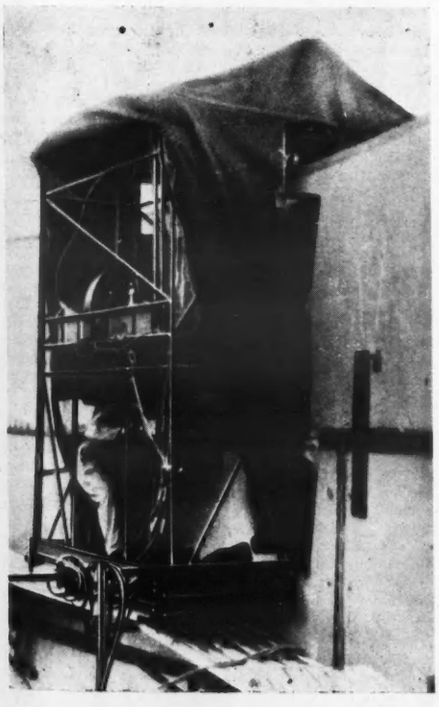
Bottling hall showing the labelling and packing machines

Launch of "Empress of Canada"

THE liner under construction at the Walker yard of Vickers-Armstrongs (Shipbuilders), Ltd., for Canadian Pacific Steamships, Ltd., was christened "Empress of Canada," and launched on Tuesday, May 10, by Mrs. J. Diefenbaker, the wife of the Canadian Prime Minister. The ship, which will be primarily engaged on the owner's passenger and freight service between Great Britain and Canada, has the following main particulars: length between perpendiculars, 600ft; breadth moulded, 86ft 6in; depth moulded to main deck, 48ft; service speed, 21 knots; service shaft horsepower, 27,000; and a load displacement of 26,800 tons. Accommodation is provided for 192 first-class and 856 tourist-class passengers, and together with the crew's quarters is air-conditioned throughout, including the enclosed promenades. Propulsion is by two sets of Pametrada designed double-reduction geared turbines, operating on a reheat cycle, and developing a maximum of 30,000 s.h.p. at 127 propeller revolutions per minute, the propellers having a diameter of 18ft. Each set consists of h.p. and l.p. impulse turbines in tandem and an l.p. double-flow reaction turbine and a Weir "Regenerative" condenser. There is also a Weir closed feed system, and a sea-water evaporating and distilling plant. Two controlled superheat boilers and one reheat boiler of Foster Wheeler design provide the necessary steam, which is supplied at 590 lb per square inch and 850 deg. Fah. to the h.p. turbine and reheated to its original temperature before entering the l.p. turbine. Each boiler is fitted with a cast iron gilled economiser and there is a Wallsend Slipway oil fuel installation, consisting of three Simplex pumping and heating plants. An auxiliary boiler of Howden-Johnson pattern supplies saturated steam at 200 lb per square inch for auxiliary purposes, both at sea and in port. To meet demands for electrical power there are two 1500kW, 225V, Allen turbine-driven generators and three 500kW Allen diesel-driven generators.

Tank Seam Welding Machine

AN automatic seam welding machine has been developed by Rockweld, Ltd., Commerce Way, Croydon, Surrey, for welding the horizontal girth seams in the construction of large storage tanks. The machine, shown in the accompanying illustration, consists of two enclosed platforms slung from an overhead carriage and hanging one on each side of the tank wall. The support carriage runs on two grooved wheels along the upper edge of the tank wall and these wheels are driven through a variable speed unit. Two travelling speed ranges are available—from 10in to 100in a minute and 80in to 200in a minute—and a clutch is used to engage the drive for positioning purposes.



Twin-head welding machine for horizontal seam welding in construction of large steel tanks

Pivoted adjustable arms on each platform support an operator-controlled automatic welding head and welding is carried out simultaneously on each side of a joint, one arc being about 1ft ahead of the other. The equipment uses the firm's "Comet" process of automatic, visible arc welding with a flex-cored wire in a protective atmosphere of carbon dioxide. Brushes in contact with the plates being welded protect the gas shielding against dispersal when a wind is blowing on the site. During welding the slag is supported by an endless chain of copper blocks which press against the plate slightly below the seam.

It is stated that, because of the deep penetration obtained, no chamfering is required when welding plate up to about $\frac{3}{8}$in thick, and that gouging is also unnecessary. For each welding head there is required a 750A welding generator of the normal drooping characteristic type and for the motors and auxiliary equipment a three-phase, 5kVA power supply.

[Reply Card No. E8712]

Diesel-Hydraulic Shunting Locomotive

A DIESEL-HYDRAULIC shunting locomotive made by Ruston and Hornsby, Ltd., Lincoln, can be supplied with either an 0-4-0 wheel arrangement for 4ft 8½in to 5ft 6in gauge or an 0-6-0 arrangement for gauges from 3ft 3⅜in to 5ft. The locomotive has a Ruston six-cylinder turbo-charged diesel engine which develops 156 b.h.p. at 1800 r.p.m. and the drive to the reverse/reduction gear is transmitted through a twin disc, three-stage torque converter. With this form of transmission the engine speed control lever controls the power developed by the engine and for any given setting the hydraulic transmission ensures that the travelling speed of the locomotive is the maximum for the required tractive effort.

Both models of the locomotive have a working weight of 28 tons and it is stated that, although adhesion varies according to track and weather conditions, the maximum starting effort of 16,200 lb can be obtained with an adhesion of 578 lb per ton. At a speed of 1·5 m.p.h. a tractive effort of 13,700 lb is obtainable with an adhesion of 495 lb per ton, and at the maximum speed of 14·25 m.p.h.the tractive effort is 2100 lb.

As can be seen in the illustration, the general design of the new locomotives closely follows that of the maker's diesel-electric and diesel-mechanical shunters. It is of sturdy, compact construction with a main frame of welded steel plate designed to withstand the severe shocks encountered in shunting work. The main power unit is enclosed in a steel plate bonnet with large removable side panels, giving free access for inspection and maintenance. Large windows of shock-proof glass in the all-steel cabin structure give good visibility in all directions and the three driving control levers are duplicated on each side of the cab.

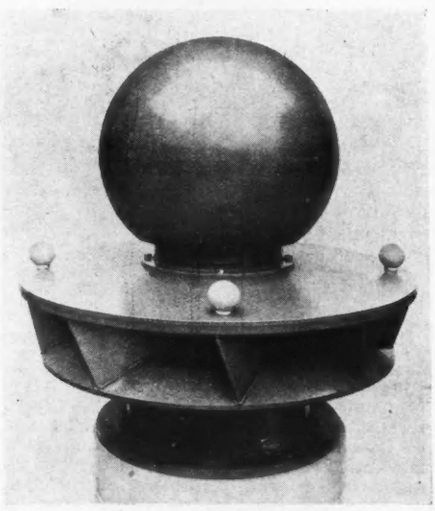
Compressed air for starting purposes is stored in a receiver supplied by a compressor belt-driven from the engine, a small petrol engine-driven set being fitted as a stand-by in the event of pressure loss in the air receiver. To facilitate engine starting and engagement of the forward and reverse gears, the engine is isolated from the hydraulic transmission by a cut-off clutch which is actuated by an air cylinder and operates on the clutch lever. Westinghouse air brakes can be operated from either side of the cab and a hand-operated screw-down parking or emergency brake actuates the main brake control linkage.

[Reply Card No. E8713]

Two 28-ton, 0-4-0, diesel-hydraulic shunting locomotives in service

Fume Fan

A FUME-EXHAUSTING radial fan, developed by Turner and Brown, Ltd., Davenport Works, Bolton, Lancs, is designed to replace conventional discharge connections and weather cowls on buildings. The fans are manufactured from rigid unplasticised P.V.C., and are made in six sizes from 10in to 25in. They are resistant to chemical fumes and corrosive gases, the only metal parts being the motor and the stainless steel bolts used for installation.



Fume exhausting fan made of unplasticised P.V.C.

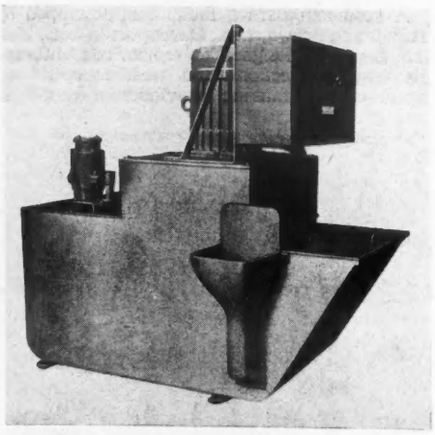
The fan is enclosed in the sphere on top of the fan and incorporates special means of ventilation to prevent overheating in warm weather. Normally these "Turbo-Dynamic" fans are of grey coloured material, but if required, they can be supplied in pastel shades.

[Reply Card No. E8714]

SHORTER REPORTS *(Continued)*

Grinding Coolant Clarifier

A CENTRIFUGE equipment for the clarification of coolants for small and medium grinding machines, and which has a rated capacity of 13 gallons a minute, has been developed by the Alfa-Laval Company, Ltd., Brentford, Middx. This "Turbomatic Minor" can be seen in the photograph we reproduce below. It has a two-



Centrifuge for clarifying grinding machine coolant

compartment tank on which the centrifuge bowl is mounted and this tank which forms a reservoir for the coolant has a capacity of 58 gallons. Contaminated coolant from the grinder is fed into the base of the larger of the two compartments where some settlement of the heavy solids immediately takes place. The centrifugal bowl, positioned a little below the surface in this compartment, draws up the partially settled coolant, clarifies it, and passes it forward to the clean coolant compartment, from where it is pumped back to the machine.

Sludge extracted by the centrifuge is retained in the bowl and discharged at predetermined intervals. This discharge is achieved by reversing the current to the motor, thereby causing a rapid deceleration of the bowl. The solids are scoured from the bowl wall by the still rotating coolant, and discharged into the tank during the slight pause before the motor is restarted. The whole operating sequence is controlled by a cam-operated timing device.

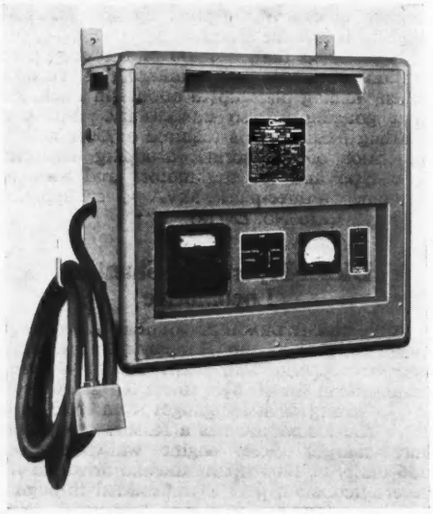
During the solid discharging period there is no cessation of coolant flow to the wheel because the clean coolant section of the tank contains ample coolant to maintain full flow to the wheel during the eight to twelve seconds required for the discharging operation. The only manual operation required on this machine, apart from pressing the two start-buttons starting the pump and centrifuge respectively, is the pressing and holding of a discharging button to ensure discharge of solids when the grinder is to be stopped for a break or at the end of the day.

[Reply Card No. E8721]

Traction Battery Chargers

INCREASING use of battery electric vehicles has shown the need for specialised charging equipment to promote long life of batteries and economic service. The charger illustrated has been introduced by Oldham and Son, Ltd., Denton, Manchester, to meet this requirement. In the model shown, a two-stage or equalising charge is obtained by means of a selector switch. For a two-stage charge the time controller on the left is set so that when a given terminal voltage is reached, the charge continues at a lower rate for a selected period. This is brought about by a relay which, in operating, changes the input to the rectifier to a lower tapping and starts a synchronous motor in the timing mechanism. A taper charger of similar specification is also available. In both versions the relay terminates the charge. The servicing facilities already provided by the company for its batteries are extended to cover the chargers, so that the setting up of the two-rate chargers is normally attended to and adjusted by the service engineer.

Single-phase mains voltage is fed to a vacuum-impregnated transformer with six primary tappings, feeding germanium rectifiers in a bridge circuit. Protection on the a.c. side is given by a small high-speed circuit breaker, which may be re-set from the front panel as seen on the right of the meter in the illustration. Two cartridge



Germanium rectifier charger with automatic two-rate charge facilities

fuses, one in circuit and the other clipped nearby as a spare, protect the equipment on the d.c. side. All heavy components are fixed at the back of the cubicle framework for stable wall-mounting. The panels are of heavy-gauge sheet metal with hammered silver-grey acid-resistant finish.

[Reply Card No. E8722]

Automatic Water Systems

A RANGE of equipment enabling fully automatic pressure-operated water supply systems to be installed in private houses, farms and institutions is now being marketed by Firth Cleveland Pumps, Ltd., of Earl Shilton, Leicester. These water systems consist of a well, a pump and a small pressure tank, no water storage tank being required. A pressure regulator on the pump is set to the pressure at which water is required to be delivered. On the pump motor being started, water is pumped from the well and into the pressure tank until the air in the tank is compressed by the water to a point when the pressure of the air is equal to the delivery pressure required. At this point the pump motor is automatically cut out, and the water is expelled by air pressure through the house pipes. When the water level in the tank, and the pressure of the air above it, drops below the regulated figure, the pump automatically starts up to recreate the balance.

The firm is making six sizes of pumps, suitable for well depths up to 180ft, with capacities up to 2250 gallons per hour, for delivery pressures up to 70 lb per square inch. Submersible pumps, for wells from 180ft to 400ft, for delivery pressures up to 80 lb per square inch and capacities to 700 g.p.h., are also available. The pressure tanks available range in size from 2 gallons to 30 gallons, and the maker points out that the larger tanks maintain delivery pressure for a longer period before the pump comes into action.

[Reply Card No. E8723]

Air Traffic Control Computer

TESTS have begun in the United States of a computer designed to meet the Federal Aviation Agency's requirements for air traffic control. The computer was designed and built by General Precision Incorporated, with which the British firm of General Precision Systems, Ltd., Aylesbury, has licensing arrangements. As a result of this connection, General Precision Instruments, Ltd., has established a division specialising in the design and manufacture of air traffic control equipment for the United Kingdom and European markets.

The new computer, which is installed in the Federal Aviation Agency's Experimental Centre at New Jersey, is capable of processing 410 aircraft flight plans, and of processing and printing 1600 flight progress strips, in an hour. Primary instruction and data storage is provided by a 4000-word magnetic core memory. The file storage system consists of magnetic drum consoles. A maximum of sixteen drums may be connected to the computer, each storing 16,000 words or identical dual records of 8000 words each for error checking. The computer will perform internal computations or an input-output message reception or transmission while a file search is in progress. All low-speed inputs and outputs such as teletype and land lines are buffered into the central computer by a high-speed buffer drum. The drum operates at 12,000 r.p.m. with a total capacity of 12,000 words. Slow-speed inputs are transferred rapidly to the computer and computer output is reduced to a speed acceptable to output devices by the buffer. The computer also communicates with the high-speed logical circuits of a wide variety of display consoles. A control panel presents the contents of important registers, counters and indicators in a visual display. Input and output can be controlled manually by push-buttons which also serve for putting a problem through the computer step by step.

[Reply Card No. E8724]

Launches and Trial Trips

REMBRANDT, cargo ship; built by Smith's Dock Company, Ltd., for The Bolton Steam Shipping Company, Ltd.; length between perpendiculars 460ft, breadth moulded 63ft, depth moulded 41ft 9in to upper deck, deadweight 12,500 tons, draught loaded 27ft 6in, service speed 13 knots; five holds, three Bipod masts, four 10-ton and six 5-ton derricks; two 200kW and two 75kW diesel-driven generators; free piston gas turbine machinery driving controllable pitch propeller; four Smith-Pescara G.S.34 free piston gasifiers, B.T.H. gas turbine 4000 s.h.p. Launch, January 29.

MISSISSIPPI, cargo ship; built by the Chantiers et Ateliers de Provence for the Compagnie Générale Transatlantique; length between perpendiculars 457ft 8in, breadth moulded 61ft 8in, depth to upper deck 39ft 0¾in, draught loaded 26ft 11in, deadweight 9600 tons, service speed 16 knots; twelve passengers; five holds, four sets of Erman hatch covers, one set of Mege hatch covers; one 30-ton one 20-ton and 5-ton and 10-ton derricks; three 350kW generators; Provence-Doxford supercharged Mark 65 L.B.D. 6S. oil engine, 9000 b.h.p. at 120 r.p.m. Trial, February.

MAURICIEN, cargo ship; built by the Chantiers Navals de la Ciotat for the Compagnie des Messageries Maritimes; length between perpendiculars 478ft 10in, breadth moulded 64ft 7in, depth to shelter deck 39ft 5in, draught loaded 26ft 2in, deadweight 9300 tons, displacement 15,000 tons, service speed 18 knots; five holds, MacGregor hatch covers, Bipod masts, one 60-ton, one 30-ton, four 10-ton and ten 5-ton derricks, sixteen electric winches; three 300kW diesel-driven generators; supercharged Sulzer 10 RSAD 76 diesel engine, ten cylinders 760mm diameter by 1550mm stroke, 13,450 b.h.p. at 120 r.p.m. Trial, February.

ARCADIAN, cargo ship; built by Henry Robb, Ltd., for Ellerman Lines, Ltd., length between perpendiculars 340ft, breadth moulded 54ft, depth moulded 31ft, deadweight 4150 tons on 20ft 8½in draught; Fairfield-Sulzer seven-cylinder oil engine, 3500 b.h.p. at 150 r.p.m. Launch, March 15.

INDUSTRIAL NEWS

Apprentices Wage Claim

An unofficial strike of engineering and shipbuilding apprentices, which in various parts of the country lasted a month, has now ended. There was a general return to work on Tuesday. At the peak of the strike, about 60,000 apprentices were said to be involved. Throughout the strike the apprentices have maintained that they were protesting at the delay in dealing with claims for pay increases which were lodged over a year ago. But the Confederation of Shipbuilding and Engineering Unions does not appear to have taken up the dates offered by the employers' organisations for discussion of the claims, with the result that the apprentices' case for a wage increase was not put before the employers until a month ago. The Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation have, however, both drawn attention to the fact that apprentices receive an agreed percentage of the skilled fitters' rate, so that they automatically receive a wage increase when there is an increase in the rate of the skilled men in the two industries.

Prices, Productivity and Incomes

The Chancellor of the Exchequer, Mr. Heathcoat Amory, has made a statement this week, in a Parliamentary written reply, as to the future of the Council on Prices, Productivity and Incomes. He recalled that from the time of its establishment (in August, 1957) up to last summer, when Lord Cohen relinquished the chairmanship, the Council had rendered three valuable reports. The Chancellor said the Government considered that those reports contributed to a greater public awareness of the basic issues involved in the field of prices, productivity and incomes, and believed there was continuing scope for further studies and advice on those matters from an authoritative independent body. It had therefore been decided that the council should be reconstituted, with Lord Heyworth as chairman. Sir Harold Howitt, who had been a member of the council since its inception, had expressed a wish to retire and his place was to be taken by Sir Harold Emmerson ; Professor H. Phelps Brown had agreed to continue as a member. The council's terms of reference, the Chancellor added, would be unchanged, namely : " Having regard to the desirability of full employment and increasing standards of life based on expanding production and reasonable stability of prices, to keep under review changes in prices, productivity and the level of incomes (including wages, salaries and profits) and to report thereon from time to time."

Iron and Steel

The Iron and Steel Board has stated that steel output in April (which included the Easter holiday) averaged 478,100 tons a week and was thus at an annual rate of 24,861,000 tons, compared with a rate of 20,139,000 tons a year earlier. Pig iron production in April averaged 310,600 tons a week which represents an annual rate of 16,150,000 tons, compared with 12,027,000 tons a year earlier.

The Board says that preliminary figures suggest that consumers' and merchants' stocks of steel may have increased by about 225,000 tons during the first quarter of the year. Consumption during the first quarter is estimated to have been about 25 per cent higher than in the comparable quarter of 1959, requiring an additional 1,000,000 tons of steel. Furthermore, the change from running down to the building up of stocks accounted for an extra 500,000 tons. Steel production, the Board points out, will be further increased this year as a result of the starting up of new capacity, though it will be partly offset by the seasonal decline in output during the holiday weeks. There may also be some reduction from the current high level of exports, partly because of increased competition and partly on account of the bigger home demand.

Ergonomics in Industry

Ergonomics, the study of man in relation to his working environment, is the subject of a three-day conference being organised by the Department of Scientific and Industrial Research and to be held at the Connaught Rooms, Great Queen Street, London, W.C.2, from September 27 to 29 inclusive. It is stated that the object of this conference is to bring recent ergonomic research and industrial application to the notice of senior people in industry and to show where ergonomics fits in with the interests of production engineering, equipment design, work study training and industrial health.

Ergonomics is, of course, concerned with the improvement of industrial efficiency by ensuring that equipment is within the mental and physical capacities of normal people, taking into consideration such factors as the complexity of the job, noise, lighting and temperature. Speakers at the conference will represent industrial concerns, medical services, the trade unions and academic institutions. They will discuss the benefits to industry of a combined approach by anatomists, physiologists and psychologists, along with engineers, to problems of " fitting the job to the man."

Further details of the conference (probable fee, inclusive of coffee, luncheon and tea, 15 guineas) can be obtained from Miss H. M. Clay, D.S.I.R., 14–18, Cornwall Terrace, Regent's Park, London, N.W.1. As accommodation is limited, early application is recommended.

Accident Prevention Report

In its report for 1959 the Safety Department of Imperial Chemical Industries, Ltd., has included a retrospect of accident prevention since 1945. This recalls that a safety section had been established ten years before the war and had made good progress, but its work was interrupted by the war. In 1945 I.C.I. employees suffered 7300 accidents, causing either lost time or alternative work, and in 1946 the figure increased to 7500. A general programme of education and publicity was introduced to combat these high figures, coupled with schemes for promoting inter-divisional competition. The progress achieved is illustrated by a graph in the report showing an almost unbroken fall since 1946 in the accident frequency rate, i.e. the number of accidents (fatal, disabling or lost time) a payroll employee might expect to have during 100,000 working hours (or his working life with I.C.I.). In 1946 the figure reached its peak of nearly 2·5, but by the end of last year had dropped to about 0·5. The present target is 0·25, or only one accident during the working life of every four employees. The safety programme has included senior management safety conferences, and the firm's publication, *Safety Bulletin*, has been re-designed to cater for the needs, not only of those whose immediate concern is safety, but of managerial and technical staff who have as an integral part of their job in production a responsibility for safety. Although in 1959 the accident frequency rate of 0·462 showed a deterioration of 2 per cent from the 1958 record, there was a steep increase in " million hour " awards to works achieving 1,000,000 man-hours without a lost time accident. These totalled twenty-nine, an increase of over 50 per cent on the previous best.

Management in an Expanding Economy

The theme of the Scottish Management Conference, which was held at Gleneagles recently, was " Management Problems in an Expanding Economy." Some of these problems were commented on by Sir Joseph Latham, deputy chairman of the National Coal Board, in an introductory address to the conference.

Sir Joseph said that the British economy in general had only recently emerged from a four-year period of stagnation. From 1955 until the end of 1958, he pointed out, the index of industrial production remained practically unchanged, but in 1959 the upward movement was resumed and by the end of the year industrial production was nearly 10 per cent higher than a year earlier. The rise was continuing, he added, and it had been suggested that a further rise of about 5 per cent might be achieved this year. Sir Joseph went on to say that, just as the effects of the recession varied from industry to industry and from area to area, so there had been an uneven pattern of recovery. It started in the consumer goods industries, and it was not until the third quarter of 1959 that there was a marked recovery in the metal manufacturing, engineering and electrical goods industries, while in shipbuilding there had been no upturn by the end of the year.

In his observations on management problems, Sir Joseph mentioned planning. One of the most commonly discussed aspects of planning, he said, related to the use of land and the location of industry. Irrespective of political philosophies, Governments were finding it desirable in practice to plan and direct the location of the principal industrial developments. It was important, also, Sir Joseph continued, that planning and forethought should be applied to the basic industries and services which a flourishing economy must have, some examples being water, fuel, power, roads and railways. When possible developments were being considered, there was a tendency to presuppose that those services would be available and to take it for granted that they would keep pace with changing needs.

PERSONAL AND BUSINESS

Appointments

MR. I. W. MUNRO has been appointed general manager of Hall Engineering, Ltd.

SIR JAMES DOAK has joined the board of directors of J. H. Fenner and Co. (Holdings), Ltd.

VICKERS-ARMSTRONGS (AIRCRAFT), Ltd., announces that Air Marshal Sir Geoffrey Tuttle has joined the company.

THE COIL SPRING FEDERATION RESEARCH ORGANISATION has appointed Mr. Henry Snow as the Organisation's first industrial liaison officer.

LIEUT.-COLONEL CHARLES GUILLAN, secretary of the Institute of Metals, has been elected an honorary member of the Société Francaise de Metallurgie.

MR. REX A. SEBASTIAN has been appointed general manager of Cummins Engine Company, Ltd., manufacturing plant in Shotts, Lanarkshire, Scotland.

MR. N. E. WILKINSON has taken up an appointment with Nettle Accessories, Ltd., to be responsible for the further development of its industrial division.

GOODENOUGH PUMPS, Ltd., states that Mr. W. J. S. Blunt, 74, Watery Lane, Redditch, Worcestershire (telephone, Redditch 1175) has been appointed Midlands representative.

BRUNTONS (MUSSELBURGH), Ltd., announces that Mr. Colin Campbell Mitchell, director of research and development of Brown Bros. and Co., Ltd., has joined its board of directors.

MR. ERIC GREENWOOD, general manager of Modern Machine Tools, Ltd., and Precision Machinery Services, Ltd., has been elected to the boards of both companies.

THE ASSOCIATION OF SHORT-CIRCUIT TESTING AUTHORITIES announces that Mr. J. R. Wilkinson, M.I.E.E., has been elected chairman in succession to Colonel B. H. Leeson, M.I.E.E.

MR. J. B. MACKIRDY has been appointed works manager of the guided weapons factory of Bristol Aircraft, Ltd., Cardiff, in succession to Mr. R. A. Burden, who has taken up an appointment with the Pyrene Company, Ltd.

ROBERT WATSON AND CO. (CONSTRUCTIONAL ENGINEERS), Ltd., states that Mr. C. Holden, chief draughtsman, Mr. T. C. Monk, commercial manager, and Mr. J. Newton, works manager, have been appointed executive directors.

MR. H. J. H. NETHERSOLE, general manager of the English Electric Company's traction department, has been appointed a director of the Vulcan Foundry, Ltd., and Robert Stephenson and Hawthorns, Ltd., members of the English Electric group.

MULLARD, Ltd., has announced the appointment to the board of directors of Mr. H. E. R. Shand, following the retirement of Mr. A. W. Welton. Mr. Welton retains his directorship of Mullard Overseas, Ltd., and will continue to act in an advisory capacity to the board of Mullard, Ltd.

GEORGE ELLISON, Ltd., announces that Mr. T. J. Rowlands, A.M.I.E.E., has been appointed chief engineer and manager of the engineering department. Mr. George Ellison, Jnr., has been elected to the boards of directors of the associated companies, George Ellison, Ltd., Alfred Ellison, Ltd., and Tufnol, Ltd.

THE MINISTRY OF POWER announces that Mr. A. J. Peech has been appointed to be a part-time member of the Iron and Steel Board with effect from June 1, in place of Mr. N. H. Rollason, whose appointment expires on May 31. Mr. A. H. Wilson has been appointed to be an additional part-time member from June 1.

THE GENERAL ELECTRIC COMPANY, Ltd., announces that Mr. G. J. Gaunt, sales manager of the Reliance Telephone Company, Ltd., has been appointed a director of that company, and has also joined the board of the Telephone Supplies, Ltd. Both companies are subsidiaries of The General Electric Company, Ltd. Mr. W. T. Ashton, A.M.I.E.E., has retired as a director of Reliance Telephone Company, and Telephone Supplies, after more than forty years' service with the companies. The assistant manager of the Reliance Telephone Company, Scottish area, Mr. R. V. Doyle, has been appointed manager of the area in place of Mr. H. J. McCusker, who has retired.

DR. P. R. HOWARD, A.M.I.E.E., has relinquished his post as head of the transmission and distribution section and has been appointed head of the high voltage laboratories at the Central Electricity Research Laboratories, Leatherhead. He will be assisted by Mr. D. F. Oakeshott, M.I.E.E., who has been appointed deputy head.

MR. M. R. B. THOMAS, temporary representative in Norfolk and East Suffolk for the Universal Asbestos Manufacturing Company, Ltd., and its associated companies, has now returned to head office at Watford to take up another appointment. He has been succeeded by Mr. J. M. Scarrott as the U.A.M. Group's permanent representative in the area.

MR. E. S. HISCOCKS, director of the United Kingdom Scientific Mission in Washington, has been appointed to succeed Dr. R. A. E. Galley as the director of the Tropical Products Institute, D.S.I.R. Dr. Galley is resigning to take up an appointment with the Shell group as research director and manager of the Woodstock Agricultural Research Centre, Sittingbourne, Kent.

KEITH BLACKMAN, Ltd., announces that Mr. C. J. Atkins, sales director, and Mr. F. W. Goodge, contracts director, have been appointed joint assistant managing directors. The following new appointments become effective from June 1: Mr. F. W. Brown, commercial manager; Mr. E. A. Manning, V. Dept. manager; Mr. R. F. Williamson, contracts manager, and Mr. P. C. Burden, chief draughtsman (contracts).

Business Announcements

MR. F. B. DIXON has resigned as managing director of Hall Engineering, Ltd.

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., has announced the retirement of Mr. G. A. Rendle, M.I.E.E., deputy general manager.

BRITISH RAILWAYS, SCOTTISH REGION, announces that Mr. W. H. Underwood, district motive power superintendent, Glasgow (South) is to retire on May 21.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the telephone number of its Liverpool branch will be altered to Maritime 2424 with effect from June 1.

CHRYSLER INTERNATIONAL S.A., has appointed J. Raven, Ltd., 43, London Road, Twickenham, Middlesex, to be its sole London distributor for "Airtemp" air conditioning room units.

MR. C. HINDER, export sales manager of I.T.D., Ltd., has left by air on a round-the-world tour, to meet the company's overseas agents and distributors, and to set up new agencies where necessary.

POLYPENCO, Ltd., 68-70, Tewin Road, Welwyn Garden City, Herts, has established a sales office at 117, Swan Arcade, Bradford, 1 (telephone, Bradford 32073), under the management of Mr. S. Sharp.

THE PLESSEY COMPANY, Ltd., announces that it has concluded an agreement with the Fansteel Metallurgical Corporation of North Chicago, Illinois, and now has exclusive selling rights in Great Britain for "Fansteel" tantalum capacitors.

MR. J. G. WINDOW, sales director of Q.V.F., Ltd., is to visit Mexico this month. He will be in New York for approximately seven weeks, in conjunction with the Q.V.F. exhibit at the British Trade Fair, to be held in New York in June.

THE STANTON IRONWORKS COMPANY, Ltd., P.O. Box No. 3, near Nottingham, announces that its subsidiary in Canada, Stanton Pipes (Canada), Ltd., which until now has been a selling company only, has been reorganised as a manufacturing company. A substantial minority interest in the subsidiary has been acquired by National Steel Car Corporation, Ltd., Hamilton, Ontario.

LAMBRETTA CONCESSIONAIRES, Ltd., states that Mr. G. N. H. Morris is no longer with the company and that, for the time being, all inquiries and correspondence relating to the public relations side of Lambretta, Trojan or Clinton interests should be addressed to: The Public Relations Department, Lambretta-Trojan Group of Companies, Trojan Works, Purley Way, Croydon, Surrey (telephone, Municipal 2499).

ELGAR MACHINE TOOL COMPANY, Ltd., 172-178, Victoria Road, Acton, London, W.3, has been appointed exclusive distributor in the United Kingdom for the vertical and horizontal broaching machines manufactured by Messrs. Varinelli of Milan.

MATCHLESS MACHINES, Ltd., T.E.S.A. division, 18, Bolton Street, London, W.1, states that Listers Wholesale (B'ham), Ltd., 143, High Street, Smethwick, Birmingham, and its subsidiary companies, have been appointed area distributors, to cover Warwickshire, Staffordshire and Shropshire.

Contracts

MATTHEW HALL AND CO., Ltd., has been entrusted with work to the value of £5,500,000 in connection with the engineering, procurement and erection of polyolefines plants and off-site facilities for Shell Chemical Company, Ltd., at Carrington, near Manchester.

W. H. ALLEN, SONS AND CO., Ltd., has been awarded, subject to the approval of the Ministry of Housing and Local Government, the contract for the main pump house machinery for the foul water portion of the new Bristol drainage scheme. The plant to be supplied comprises six 33in vertical-spindle suspended mixed-flow pumps driven by four constant-speed and two variable-speed a.c. motors. The contract includes the high and low-voltage control gear and the power transformer. It is valued at £138,962.

RICHARD COSTAIN (CIVIL ENGINEERING), Ltd., at present completing a run-up area and stopway at Manchester Airport, has been awarded a £700,000 contract by Manchester Corporation for the construction of a new terminal apron and other work. The apron will be 220,000 square yards in area and involve the placing of 100,000 cubic yards of concrete. The other work includes storm water drainage, water supply, bulk refuelling and extensive lighting system, and earthworks. The works have been designed and will be supervised by the Manchester City Surveyor's department (City Surveyor and Engineer—Mr. Rowland Nicholas, M.I.C.E.). The first stage of the new terminal building, valued at £450,000 is now being constructed by R. Costain and Sons (Liverpool), Ltd. (City Architect—Mr. L. C. Howitt, F.R.I.B.A.).

THE A.E.I. CONSTRUCTION (CABLES AND LINES) DIVISION has commenced work on a new railway cable contract awarded to it by the British Transport Commission. The contract, valued at over £150,000, covers the supply, supervision of laying, jointing, &c., of some 24 miles of 33kV three-core oil-filled cable with aluminium conductors along various sections of the main London to Brighton Line. These sections are between the following sub-stations: South Croydon–Purley–Star Lane, Salfords–Gatwick. The C.E.G.B. supply point at Three Bridges–Balcombe–Ouse Valley, Preston Park–Brighton–Portslade. The C.E.G.B. supply point at Fishergate–Shoreham and also one section in Kent between Chislehurst and Chelsfield sub-stations. The contract also includes the supply, supervision of laying and jointing of a new twelve-core plastic pilot/supervisory cable along most of the route, and the supervision of the transferring of existing pilot cables from the wooden trunking in which they are at present laid to the new surface concrete troughing.

THE HEAD WRIGHTSON MACHINE COMPANY, Ltd., has received an order from Richard Thomas and Baldwins, Ltd., for the supply of five steel strip cut-up lines for the new Spencer works. These lines are expected to be in full production by October, 1961. In addition, Colvilles, Ltd., has placed an order with the company for the supply of two steel strip lines to deal with hot rolled material, one up to $\frac{7}{16}$in thick and the other up to $\frac{1}{4}$in thick, and generally similar to those which are to be supplied to Richard Thomas and Baldwins, Ltd. Two of the lines for the Spencer works will be designed to handle hot rolled material, one for thicknesses of up to $\frac{7}{16}$in, and one for handling material up to $\frac{1}{4}$in thick. Both of these lines are designed to operate at speeds of up to 300ft per minute and to handle coils weighing up to 30,000 lb. The three remaining lines are designed to handle cold rolled strip. Two of these will be handling material in coils of up to 60,000 lb weight and 0·105in maximum thickness; the third line for the handling of cold rolled material is designed to deal with very thin steel strip.

CONTINENTAL AFFAIRS

by Our Continental Editor

Water Turbine Laboratory at Kristinehamn

AT the present time the state of the art of turbine design and manufacture has reached such a pitch that only minor improvements seem possible. However, with the large and very large units which are being installed, such improvements usually represent a distinct gain in the economy of a project which is well worth striving after. It is for this reason among others that the leading turbine manufacturers are building first-rate laboratories in which research work of the necessary degree of precision may be carried out. A second important reason is the desire to obtain data upon which a performance guarantee may be based. To carry out a full series of tests on the actual installation is a time-consuming procedure which is very costly on account of the large capital sums involved. In order to avoid the need for such expense, it has become customary to use models instead, and to scale up the results in accordance with the laws of similarity.

The hydraulic laboratory of Karlstads Mekaniska Werkstad A.B. (K.M.W.) at Kristinehamn, which was substantially completed last year, is a good example of such an installation. It constitutes the latest of a series of turbine testing facilities, the earliest of which goes back to the year 1906. It will be recalled that K.M.W. has occupied a leading position in the history of water turbines and in particular of the Kaplan turbine (the first contact with Professor Kaplan dating from 1913, while the major development work began in 1921). After modernising the early laboratory in 1915, a high pressure test bed was added in 1918 (in connection with an order for five 14,500 h.p. Pelton turbines for Rjukafos power station in Norway). A larger laboratory was built in 1942, but even this was outgrown within a comparatively short time, and in consequence the erection of the present building was decided upon in 1956.

The Kristinehamn laboratory is housed on three floors in a building 40m long by 12m wide by 12m high. Among the principal facilities are an open flume, a cavitation tunnel, and a high head tunnel. Space has been allowed for the later installation of a wind tunnel.

Open Flume Circuit

The open flume is intended for precision measurements of the efficiency of Kaplan and Francis turbines. For this purpose it is possible to install and test a scale model of the complete layout from the turbine intake to the mouth of the draught tube. The circuit is situated in the basement of the building and comprises a rectangular storage basin holding approximately 800 cubic metres and having a depth of 3·5m.

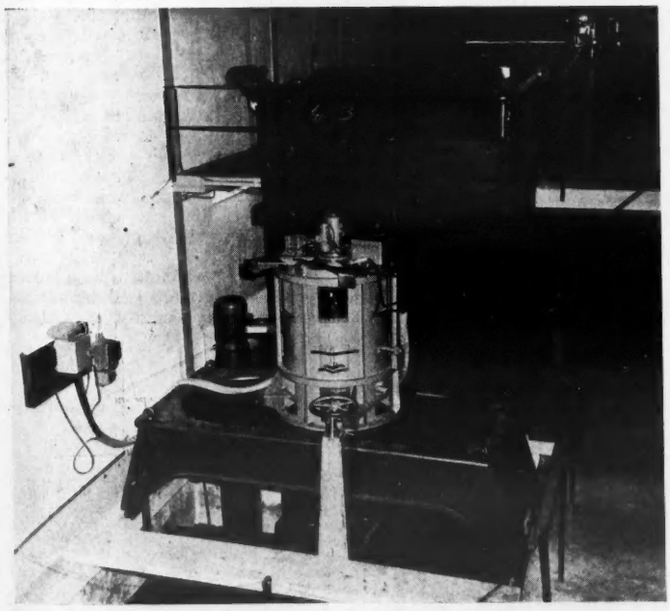
At one corner of the rectangle a 200kW vertical Kaplan pump raises the water through a head of about 5·5m and discharges it into the flume. The cross-section of the flume is 2·4m wide by 1·6m deep. At each end potentiometers connected to floats continuously measure the water level and operate the setting of the pump blades by means of an oil-hydraulic servo. From the pump centre line to the vertical front wall of the flume there is a distance of 20m. The depth increases towards the front wall, the bottom curving downwards so as to form a 7m deep pit into which the water enters smoothly. The vertical front wall makes it possible to connect models at any suitable level (Fig. 1). Intake and casing of the model are dry, which makes it much easier to carry out adjustments and make observations; the draught tube is submerged.

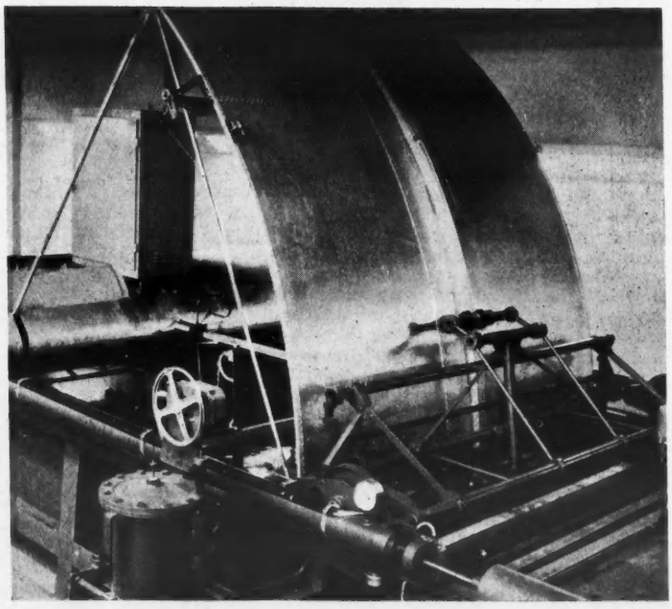
Over a sufficiently long length of the flume, the section is uniform. In this section a travelling screen is installed for the high precision measurement of the flow rate.

The screen, shown in Fig. 2, is sector-shaped. Before immersion it is speeded up to the approximate velocity of the water so that the disturbance is minimised; maximum clearance at the edges is 3mm. Constructed of light alloy, the screen weighs only about 15 kg per square metre, but its stiff construction and the manner of its suspension ensure that its shape and angular position relative to the flume axis remain unchanged over the measuring distance.

That distance is only 4m which, however, is quite sufficient on account of the high accuracy with which the timings are carried out. The screen is electrically driven in such a manner that the water resistance is automatically maintained within ±1 kg weight. The time for the screen to travel over a fixed distance is measured digitally by a decade counter counting the pulses from a 10 kc/s crystal-controlled oscillator which forms the time standard for the whole installation.

At the start of the measuring distance the counter is operated by an electric contact and at the end of the distance it is stopped in the same way. During this time the water level is measured by means of a float which operates a transducer. After passing the measuring distance,





Figs. 1 and 2—(Left) Kaplan model turbine with electric brake installed in the open flume test stand. (Right) Travelling screen ready for starting

CONTINENTAL AFFAIRS *(Continued)*

the screen is raised, the carriage braked and returned to the starting point.

Owing to the careful layout of the sloped section of the flume bottom, the water near the turbine intake is very calm. On the downstream side there is ample space for installing draught tubes of a large range of shapes and sizes. The turbines conform to the standards laid down by the Swedish State Power Board, which prescribe a runner diameter of 500mm.

After passing a right-angled corner equipped with turning vanes, the water reaches a regulating gate comprising a metal wall in which are set six conical valves. These are continuously and automatically operated by an electro-mechanical servo, actuated in a manner similar to the pump runner by two level indicators. In this way the downstream level is kept constant at a preselected value. The valves can be closed completely, and when this has been done the basin, which has a capacity of 140 cubic metres, may be used as a calibrating basin. In such cases, a servo-operated deflector knife mounted at the top of the gate is used for directing the water either into the calibrating basin, or into the downstream discharge channel. The discharged water turns through a second right angle, and then continues straight for 12m, when it passes through stilling screens, and after another 10m drops over a sharp-crested measuring weir. At a distance of 5m to 6m above the weir a number of flow meters are installed. After falling over the weir the water is back in the main storage basin.

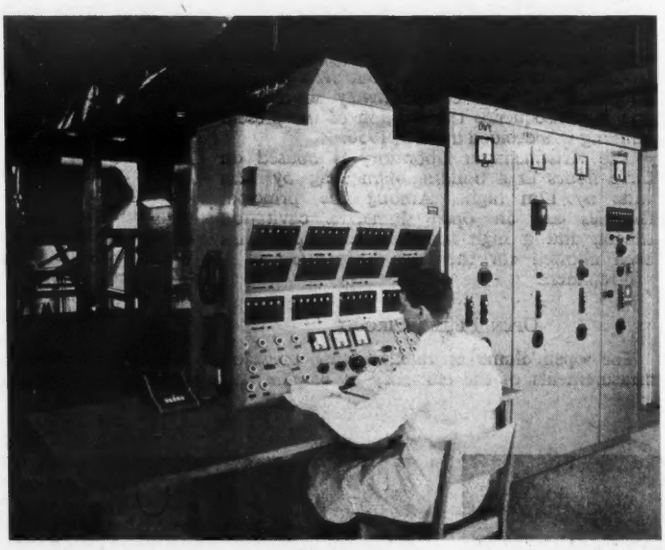


Fig. 3—Central control desk, showing decade counters for automatic measurement of the test quantities

In the ordinary efficiency tests, the quantities which have to be measured are : head, rate of flow, and turbine torque and speed. The rate of flow is obtained by means of the travelling screen, or alternatively, by using the weir which is calibrated with the help of the travelling screen. The head is normally measured as the static head, taken as the difference between the free water levels in the flume in front of the turbine and in the tail-race just over the draught tube outlet.

Turbine output is absorbed by an electric dynamometer swinging in counter-rotating bearings (so as to minimise friction), and automatically regulated to maintain set speed with an accuracy of one part per thousand. Such a degree of accuracy means an important contribution to the stability of the circuit as a whole. The torque is obtained by weighing, and the speed of rotation by counting the impulses from a toothed wheel on the turbine shaft. For the instantaneous information and guidance of the operator, an electric tachometer is additionally fitted.

Each series of measurements is initiated by the operator pressing a button at the control desk (Fig. 3). The test is then carried through automatically. For this purpose the screen as it travels passes over a number of equally-spaced electric contacts giving a sequence of five or ten impulses. Each of these impulses releases one single measurement of each of the quantities mentioned. The results of these measurements are indicated as averages on decade counters, where they may be read off or photographed by a camera. Other measurements may also be taken, such as, for instance, the axial thrust.

Float Level Indicators.—The float level transducer, which is employed for all kinds of level measurements, comprises a 250mm diameter float inside a cylinder connected to the water channel by a tapping point in such a way that no errors are caused by water velocity, surface waves, or dynamic phenomena. The float is suspended from a steel wire which passes over a pulley mounted on ball bearings and carries at the other end a counterbalance weight. In this way the water level is converted into angular position of the pulley shaft. An arm is fastened to the shaft fitted with a light source and a photocell. The radially directed light beam is chopped by a rotating drum whose shaft is concentric with the pulley. The drum is driven over gears by a synchronous motor operating on a 50 c/s frequency obtained by dividing the output of the 10 kc/s oscillator. Another set-up of light source and photocell is mounted on a fixed arm.

The drum has three pairs of axial slits along its circumference. When a slit passes the fixed photocell the decade counter is set counting at the rate of 10 kc/s ; when a second impulse is obtained from the movable arm the counting is stopped. With a drum speed of 100 r.p.m., and a drum circumference of 600mm, one unit in the counter corresponds to a deflection of the float of 0·1mm. For purposes of control and calibration, the cylinder is fitted with an overflow weir which can be operated at any time by means of magnetic valves, and which gives a well-defined reference level.

The float-level transducers are used to measure the upstream and downstream levels, the static head (by difference), the flume depth, measuring weir level and calibration basin level. The absolute values of the reference levels for all float-level transducers were calibrated and adjusted with the help of precision levelling instruments.

Speed Measurement.—As has been mentioned, the speed of the runner is obtained by counting the impulses given to an inductive pick-up by a toothed wheel fitted to the runner shaft. A gear with 100 teeth has been found to give good resolution. The counting period is obtained by using the 10 kc/s frequency standard. As the measuring time is chosen equal to that required by the travelling screen, the time readings cancel in calculating the efficiency. This has the effect of further improving accuracy.

Torque.—Measurements of the torque are carried out with a " Toledo " indicating mechanical balance, using an optical scanner. This consists of an optical grid with 1200 lines on a length of 2in. A rotating mirror sweeps a light beam over the grid, and a photocell gives impulses to a decade counter, thereby counting the lines passed by the beam. A masking screen is connected to the balance indicator, so that the number of lines uncovered is proportional to the weight measured. Full deflection is 60 kp, corresponding to 1200 units on the counter, but by means of four remotely-operated weights the range may be extended to 260 kp. During one traverse of the travelling screen, five individual torque readings are automatically obtained and averaged. The system is calibrated by applying precision weights at the dynamometer end, so that the effect of the transmission is taken into account in the calibration.

As a result of the low-friction dynamometer suspension, the sensitivity is 10 gramme-metres.

Taking all factors into account, the efficiency

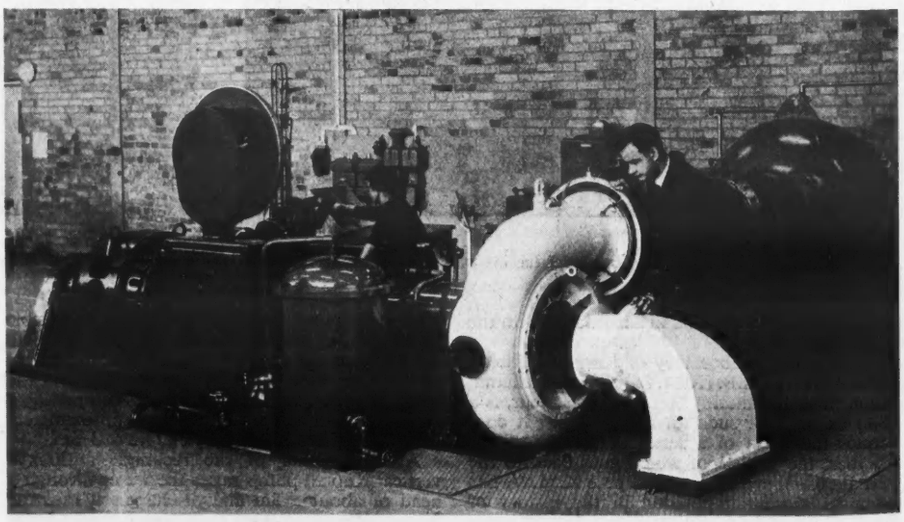


Fig. 4—Test section of cavitation tunnel with a model pump turbine undergoing tests. The model runners are of standard size (500mm diameter). Much use is made of plastic reinforced glass fibre for the construction of scrolls and discharge tubes

measurements are estimated to be correct within ±0·2 per cent, and probably better.

Cavitation Tunnel

The second main testing facility at the K.M.W. Laboratory is a cavitation tunnel (Fig. 4) for scroll case and tubular turbines. The available head is 1m to 6m, and the models can be subjected to normal operation and performance tests, as well as cavitation and runaway tests, under conditions of Froude similarity. Among the special tests may be mentioned idling at synchronous speed (so-called discharge operation).

High Head Tunnel

For testing at static heads of up to 100m a high head circuit has been installed. Its pipes have a diameter of 1m, and are arranged in such a way as to facilitate the installation of the test turbines and any alterations in the layout which may become desirable. A maximum flow of 1 cumec is provided by two centrifugal pumps, the runners of which can be locked for carrying out model pump tests. The flow rate is measured by means of venturi meters.

Much thought has been devoted to keeping the plant flexible so that turbines of widely differing designs and layouts may be tested. The total installed pumping capacity is about 1MW. About 1000 cubic metres of water is stored for the various experimental circuits. The water is continuously filtered and sodium nitrite is added so as to protect immersed steel parts from rusting. For the construction of models a special workshop has been installed in an annexe of the main laboratory building.

European Energy Problems

FOLLOWING the reports on the energy situation prepared for the Organisation for European Economic Co-operation in 1955 by Monsieur Louis Armand, and in 1956 by the Hartley Commission, the Council of the O.E.E.C. decided on November 23, 1956, to set up a permanent group of experts to maintain a continuous survey of the problems of energy in Europe and to advise on matters of general significance. The members of this Energy Advisory Commission, whose chairman is Professor Austin Robinson, of Cambridge University, act as independent experts and not as official representatives of their countries of origin. A report by the Commission was discussed by the O.E.E.C. Council on December 11, 1959, and has now been published.*

The principal change in the situation since the Hartley Report has been a slowing down in the rates of growth of most of the economies of Europe. As a result, the sellers' market in fuels which had been in existence since early in the war gave place to a buyers' market. Imported fuels grew to be a serious competiton for those produced domestically, especially in view of the fall in shipping freight rates. This competition is likely to continue. The constant search for oil has led to important discoveries in Venezuela, West Africa, and Libya, and in particular in the Sahara, while natural gas deposits have been brought into production in the Sahara, in France, and elsewhere.

On the basis of the Hartley Report, the Council of the O.E.E.C. issued certain recommendations to member countries regarding the development of primary energy production, including technical improvements in the coal industry. Measures taken in conformity with these recommendations are now becoming effective. The indications seem to be that indigenous production of primary energy in the O.E.E.C. is potentially higher than had been estimated, apart probably from coal.

Figures for the consumption of primary energy in the recent past are shown in Table I. It should be noted that these refer to the metropolitan areas of O.E.E.C. countries (thus excluding North Africa). As the statistics were prepared before the admission of Spain to O.E.E.C., that country is also excluded. In addition to the principal commercial fuels (coal, lignite, natural gas, crude oil, and hydro-power), some non-commercial sources, such as wood, peat, and wind-generated electricity, &c., are of some local importance, and estimates of their contribution have been included, as well as the effects of nuclear energy. In passing, it may be noted that the increase in energy consumption in Europe since the 1860s, the earliest period for which reliable data are known, has increased about thirty-fold.¶ Most of the primary fuels are transformed before consumption into such secondary forms as electricity, manufactured gas, coke, and petroleum products.

From its survey of present trends, the Energy Advisory Commission concludes that long-term rates of growth of the European economies will continue to be higher than those of the pre-war period. Between 1955 and 1965, the Commission forecasts an increase in consumption of 25 to 35 per cent, equal to about 200 million to 270 million tons of coal equivalent, and 58 to 83 per cent between 1955 and 1975. These forecasts are considered to be likely average values over the whole of the period in question, and make allowance for moderate short-term recessions and periods of more rapid advance. For this reason the Commission expressed the hope that long-term projects would not be greatly curtailed or postponed because of doubts about future growth.

The other principal conclusion which the Commission has reached is that any persistent long-term shortage of primary energy is unlikely by 1975, whether of oil or other fuels ; no serious difficulties of obtaining supplies from abroad are expected, in view of the great diversity of actual and potential sources, and the expected ability of European countries to pay for those supplies.

When formulating a long-term policy, says the Commission, the prime considerations should be a plentiful supply of low-cost energy, together with a freedom of choice to the consumer. Competition between different sources of energy should be fair and distortions must either be eliminated or adequately compensated. While continuity and regularity of supplies are important, long-term protection or artificial encouragement of indigenous sources of energy are not considered the most satisfactory way of obtaining such security. The general interest, in the opinion of the Commission, is best served by placing the least possible obstacles in the way of economic development of the newer and cheaper forms of energy ; although, as regards nuclear energy, it must be realised that even by 1975, nuclear power stations will not supply more than a small fraction of the total demand.

The investment necessary for ensuring future energy supplies is considered to be within the capacity of the European economy.

Prices should fully reflect the cost and scarcity of individual kinds of energy, and price differentials should be such as to ensure that each form of energy is used to the best advantage. The future of hard coal will depend upon whether the upward drift in the relative cost of European production can be arrested ; if not, the market is likely to contract further. The best way of stabilising production costs appeared to be to concentrate upon those collieries where the prospects of higher productivity were greatest. A more flexible price of coal, it is suggested, would be preferable to a stabilised price in all circumstances, whether of scarcity or surplus.

The Commission thinks that the future of coal largely depends upon increased transformation into secondary forms of energy which are easier to distribute and more convenient to use. When formulating their energy and general economic policy, governments should bear in mind the social and human problems which a reduction in coal production would entail.

Although there is a high degree of uncertainty attached to nuclear developments, it may be expected that nuclear energy will become more fully competitive by about 1970 to 1975. The changed long-term prospects of energy demand appear to call for a revision of the nuclear plans.

It is one of the major problems of the energy economy of Europe to find new markets for coal and also for natural gas. Transformation into secondary energy may help, and markets should be cultivated in the economically less advanced member countries whose consumption is at present low. This, says the Commission, calls for an examination by the O.E.E.C. of the possibilities of closer physical integration of energy supplies in Western Europe.

TABLE I—*Consumption of Primary Energy in the O.E.E.C. Area**

Year	Coal, 10^6 tons	Lignite, 10^6 tons	Natural gas,† $10^9 m^3$	Oil, 10^6 tons	Nuclear energy (net electrical output), TWh.‡	Hydro power (net electrical output), TWh.	Other forms (coal equivalent), 10^6 tons
1938...	471·1	76·5	—	32·0	—	59·7	20
1948...	420·7	78·8	0·5	40·4	—	85·4	20
1949...	444·1	86·0	0·7	47·3	—	82·5	20
1950...	447·4	90·0	1·1	55·9	—	99·0	20
1951...	492·0	99·6	1·7	67·7	—	112·8	20
1952...	485·1	100·2	2·3	72·1	—	119·7	20
1953...	472·6	101·8	3·3	79·1	—	121·4	20
1954...	485·3	109·6	4·2	92·6	—	132·5	20
1955...	508·9	116·0	5·3	106·6	—	139·2	20
1956...	520·8	120·4	6·5	122·4	0·1	146·7	20
1957...	513·0	124·7	7·3	122·7	0·4	152·2	20
1958...	473·3	124·4	7·7	142·4	0·3	172·8	20

* Including bunkers for ocean-going vessels and balance of foreign trade and stock changes in secondary forms of energy.
† At 9000 kcal per cubic metre, including methane from collieries.
‡ 1 TWh = 10^9kWh.

TABLE II—*Energy Content and Coal Equivalent of Principal Fuels*

Quantity	Energy content, 10^{12} kcal.	Coal equivalent, 10^6 tons
10^6 tons hard coal	7·0	1·00
10^6 tons coke	6·7	0·96
10^6 tons patent fuel	7·0	1·00
10^6 tons lignite	2·0	0·29
10^6 tons lignite briquettes	4·8	0·69
10^6 tons liquid fuels ...	10·0	1·43
$10^9 m^3$ natural gas	9·0	1·29
$10^9 m^3$ manufactured gas...	4·2	0·60
1 TWh = 10^9kWh hydro-electricity	—	0·40
1 TWh = nuclear electricity	—	0·40*

* At 2800 kcal/kWh = 31 per cent efficiency. Such an efficiency, it is assumed, will be reached in 1975.

* "Towards a New Energy Pattern in Europe." Report of the Energy Advisory Commission of O.E.E.C. Paris : The Organisation for European Economic Co-operation, 2, rue André-Pascal, Paris (16e). Obtainable from H.M. Stationery Office, P.O. Box 569, London, S.E.1. Price 9s.

Institute for Nuclear Fusion

Work is progressing at the Nuclear Research Centre of North-Rhine-Westphalia, near Jülich, where the Institute for Nuclear Fusion has been completed, and the Institutes for Reactor Development and Reactor Materials will begin to function in the course of the summer. Further departments which are being set up are concerned with reactor elements, biology and protection from radiation. Buildings housing various service sections are also under construction, and an Institute of Medicine is to be begun soon.

The overall construction programme involves the building of two reactors ("Merlin" and "Dido"), ten institutes, and the necessary lecture theatres, services, and communal installations. Steps have been taken to make the layout of the buildings sufficiently flexible to allow for possible alterations in emphasis and for the later inclusion of new lines of research. The first stage of the programme is due for completion in 1961. Total costs to the Land Government will amount to about DM.85 million.

Progress of Aluminium Construction in South Africa

By OUR SOUTH AFRICAN CORRESPONDENT

THE following three examples of recent aluminium construction work in South Africa indicate the progress being made in this line of development in South Africa.

Aluminium Aircraft Hangar

More than 37 tons—60,000 square feet—of aluminium alloy building sheet were used to roof and side the 257ft by 140ft Union Defence Force aircraft hangar at Louis Botha Airport. An exterior view of the hangar is shown in Fig. 1. Corrosion resistance was a key problem in the choice of the cladding material, and the designers overcame this by using aluminium, the ability of which to resist corrosion attack even in the severest marine and industrial climates is well known.

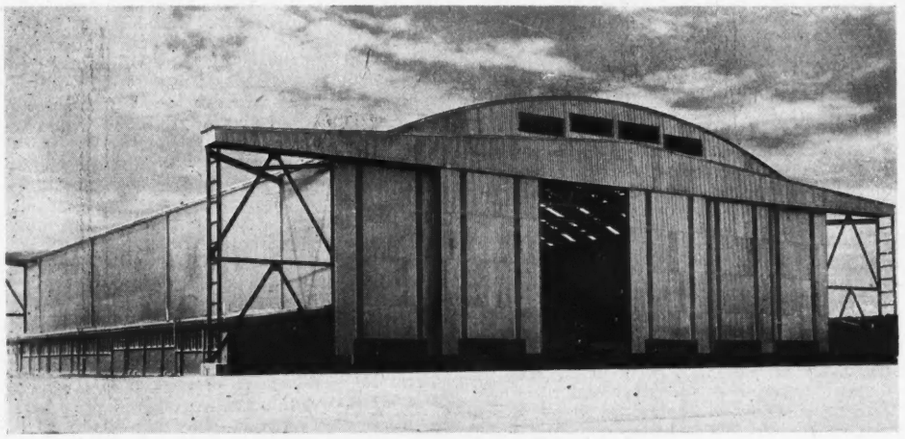


Fig. 1—A general view of the new 257ft by 140ft Union Defence Force aircraft hangar at Durban's Louis Botha Airport. More than 60,000 square feet of aluminium alloy building sheet were used to clad the roof and sides of the hangar

Some 26 tons of Acosa's 3SH 20 S.W.G. "Longspan" building sheet were used to clad the sides of the hangar, the 40ft doors at both ends, and to roof the offices alongside the building. The curved roof comprises 11½ tons of Noral Industrial 6—a sheet wider than "Longspan" but with an identical asymmetrical profile. This was supplied by Acosa from its United Kingdom associate, the Northern Aluminium Company. Aluminium alloy fasteners have been used throughout, and wide purlin spacing is, of course, a feature of the building. To provide even lighting throughout the building, an interior view of which is shown in Fig. 2, the designers incorporated translucent glass fibre sheets with the same profile as the aluminium building sheet into the roof and 40ft doors.

Flashings, gutterings and downpipes were formed from aluminium alloy sheet, and the gutter brackets along the length of the hangar were fabricated from extruded 50 S.W.P. flat bar. The Lewis Construction Company (S.A.), Ltd., was responsible for the cladding aluminium building sheet, the extruded sections being supplied by the Aluminium Company of South Africa (Pty.), Ltd.

Aluminium Mine Cages

Lightweight corrosion resistance and strength are the design features of three triple-decker all-riveted aluminium alloy mine cages recently built for a Witwatersrand gold mine, and shown in Fig. 4. The total weight of each cage is just under 2 tons—1·4 tons of steel and ½-ton of aluminium. The weight saved by the use of aluminium amounts to about 1 ton, and has enabled each triple-decker unit to replace existing double-decker steel cages without necessitating any alterations to existing winding gear. The top of each of the cages, bridles and draw gear are fabricated from steel. The cages hang in the bridles and are held at the top by means of hooks on to a 3in solid steel bar going through bridle and cage. Pins and lugs hold the bottom of each cage to the bridle. This method of attachment enables the cages to be quickly and easily removed and replaced by skips when desired.

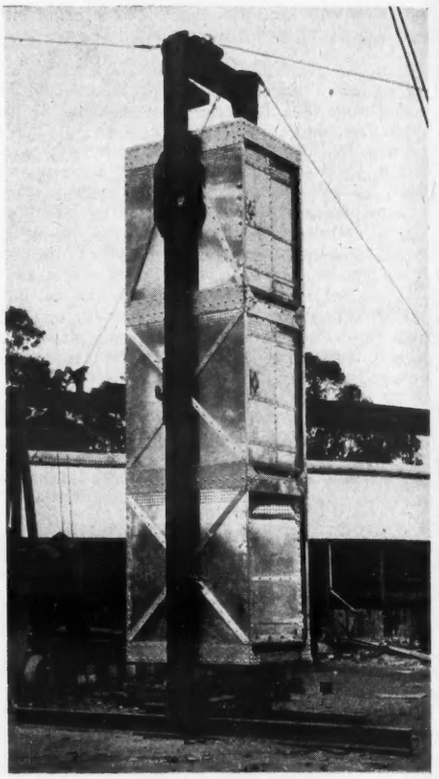


Fig. 4—A triple-decker all-riveted aluminium alloy mine cage, one of three recently constructed for a Witwatersrand gold mine

B51 S.W.P. extruded aluminium sections and M57S half hard sheet supplied by the Aluminium Company of South Africa (Pty.), Ltd., were

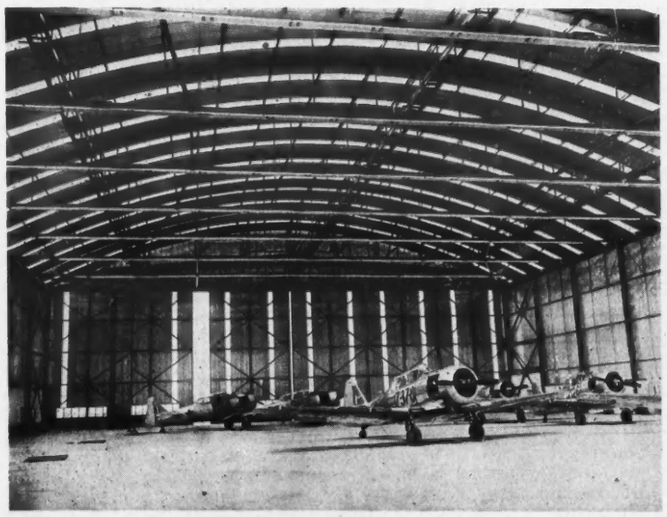


Fig. 2—Translucent glass fibre sheets incorporated into the roof and doors of the hangar provide even lighting. Corrosion resistance and wide purlin spacing are important design features made possible by the use of aluminium

Fig. 3—Aluminium alloy bakery shelves in use at the Victoria Bakery, Salisbury. They were made by N. Byford and Co. (Pvt.), Ltd., also of Salisbury, from metal supplied by the Aluminium Company of South Africa (Pty.), Ltd.

used for the job. B51S is a structural alloy, the typical strengths of which, in the two most commonly used conditions, are shown in the following table :

Condition	0·1 proof stress, lb per square inch	U.T.S. lb per square inch
B51 S.W.	22,400	35,800
B51 S.W.P.	39,000	45.000

Aluminium Bakery Shelves

Strength, elegance and cleanliness are the salient features of these functional aluminium alloy shelves made for the Victoria Bakery of Salisbury, Southern Rhodesia. The material for the shelving was supplied by the Aluminium Company of South Africa (Pty.), Ltd. An illustration of the shelving is shown in Fig. 3. Uprights are formed from 3S half hard 14 S.W.G. by 3in wide coiled sheet. The shelves, braced with extruded aluminium top hat sections, are made from 20 S.W.G. 3S half hard flat sheet and fixed to the uprights with $\frac{1}{4}$in by $\frac{3}{4}$in aluminium alloy seam bolts and nuts.

Advantages of the shelves are that they are completely hygienic—they will never rust and are easy to clean—and they can easily be dismantled for re-erection in another part of the bakery, if desired.

The Cold Storage Commission has tested a prototype unit for the past nine months under cold storage conditions, and reports that the unit is still in perfect condition.

Aerial view of Durban harbour

Durban Harbour Improvements

Although much has been done by way of improvements to Durban harbour during recent years, a further large programme of work is being undertaken. Tenders were recently invited for the dredging of a 1400ft turning basin, certain reclamation work at Island View, and the construction of a new berth (No. 8), also at Island View. This work is expected to take two years to finish. The accompanying aerial view of the harbour includes the Bayhead, where further ship repair facilities are being provided. The oil sites and tanker berths can be seen in the left background, while the graving dock appears in the left foreground.

The new programme to enlarge the turning basin has the demands of still bigger oil tankers in view. The present depth of water is 35ft and this is not considered deep enough for the bigger oil tankers which will soon be operating to Durban. Below, we illustrate an oil tanker being dry-docked at Durban. The giant tankers, which are becoming almost regular customers of the Sturrock dry dock at Cape Town, are of 85,000 tons.

A contract has recently been awarded to a South African firm for further work on Durban harbour. This includes a new shed, 900ft by 120ft, which is being built at " M " berth. The upper floors of this shed will be equipped with precooling chambers of 4000 cubic tons capacity and an adequate passenger terminal. No sheds were provided when the " T " jetty was built in 1942. Recently, a shed, 600ft long and 120ft wide, was completed at " L " berth.

Ship repair facilities are being provided at the Bayhead and will include a concrete jetty 700ft long and 40ft wide. Coasters will be served at Maydon Wharf, the timber wharves of which have been rebuilt with steel sheet piling, and a sprinkler system installed at the cargo sheds.

Cranes are playing an important part in all these improvement plans. A new 40-ton floating crane is being acquired and also many other cranes. Twelve of the new cranes will replace old cranes which are being transferred to Maydon Wharf for use by coasters and thirteen additional cranes are being procured.

Track Improvements on S.A. Railways

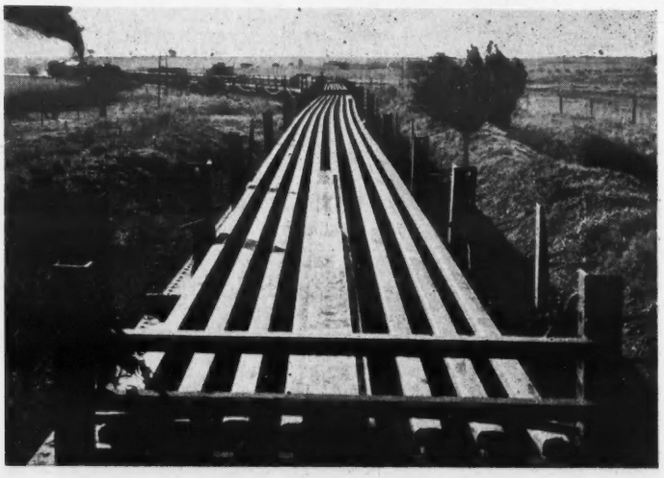
It is anticipated that during the next five years all main line railway tracks in the Union will be relaid with rails, each of not less than 120ft in length. For the traveller this means greater comfort in that the familiar " click-clack " will be reduced by at least two-thirds. Searching tests have proved the advantages of longer rails, including lower maintenance costs, longer life and greater travel comfort. The longer rails are made by welding together three standard 40ft lengths at the welding depots by means of the flash-butt system. When conditions justify very long rails, in excess of the 120ft length, thirteen 40ft lengths are welded together at the depot into a 519ft rail and these are taken to the site, where they in turn are welded together into lengths of up to half-a-mile, depending on local conditions. The illustration shows a train load of long-welded rails *en route* from the welding depot to site.

At the same time, and with the advent of steel and concrete sleepers and new methods of signalling and train control such as remote control of unattended sidings and centralised traffic control, ways and means of insulating the track are being investigated.

An interesting development in relation to rail improvements is that rails with a manganese content of up to 2 per cent are to be used by the S.A.R. to counter heavy wear on curves. Their longer life is expected to offset their higher cost.

An order for this special kind of rail has been placed with the South African Iron and Steel Corporation (Iscor) for delivery during the present financial year. This class of rail originated in Austria, from where the railways obtained 1000 tons for experimental purposes. After five years' use, the rails have been found to be so

Docking a large tanker at Cape Town



Trainload of long-welded rails

good that they have not worn to a degree where it is possible to indicate their life expectancy. Iscor is to supply 1000 tons of 96 lb rails of this kind to the South African railways and the Rhodesian railways have ordered 1200 tons a month.

East London Harbour

CONTINUATION of the project to enlarge East London harbour was marked in October, 1959, by the second stage in the harbour improvement scheme. The main reason for the decision to enlarge the harbour arose out of the decision in 1956 by the Union Castle Company, to build two new ships, the "Pendennis Castle" and the "Windsor Castle," both of which were to be larger than any ships at present using this harbour. The nautical authorities stated that these big ships could neither be brought in nor turned in the harbour with the necessary degree of safety unless further additions and improvements were effected.

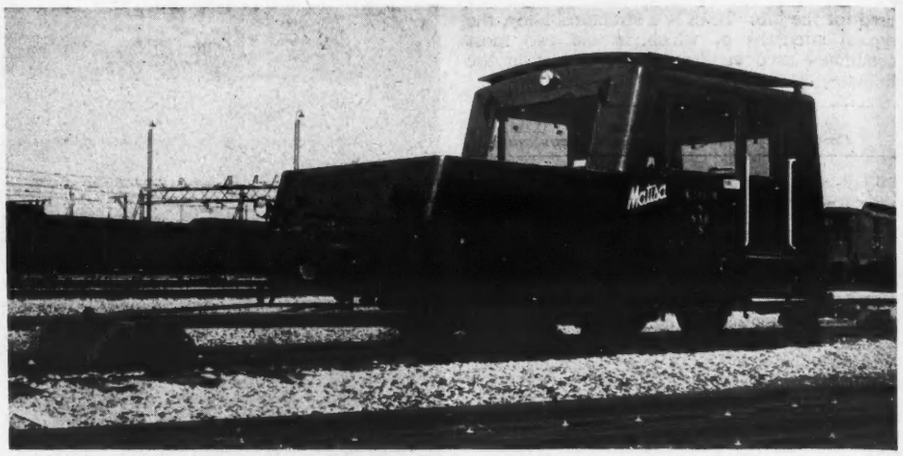
The following information is derived from the opening speech by the Minister of Transport, the Hon. B. J. Scholeman, during the first stage of the improvement operations, in November, 1958. After extensive discussions and investigations into the proposed harbour development scheme, plans were accepted for : (*a*) an entrance channel 600ft wide with vertical roundhead to the East Pier ; (*b*) a vertical wall in place of the western training wall ; (*c*) the deepening of the whole width of the entrance channel to 35ft L.W.O.S.T. (low water ordinary spring tide) ; (*d*) a 1200ft wide by 1800ft turning basin ; (*e*) a new quay, 1270ft long, equal to two commercial berths, on the western side of the widened turning basin ; (*f*) a new quay, 850ft long, at the southern end of the western side of the enlarged turning basin, for use as an oil tanker berth ; (*g*) depth of water in the enlarged turning basin area, at the commercial and tanker quays, to be 35ft L.W.O.S.T.

The scheme was started in March, 1957, and the work is being carried out in three stages. By the time the whole plan is carried out, 1,250,000 cubic yards of spoil will have been removed and 2530ft of new wharves and protective walls will have been constructed. Of the rock to be moved, approximately 400,000 cubic yards are under low water. Electric craneage is to be considerably improved along with other handling improvements.

In the first stage of the scheme the area blasted was composed of 800 tons of rock and earth. From the water side, underwater blasts had accounted for 350,000 tons of rubble. Drilling operations included 9½ miles underwater and about 29 tons of explosives had been used to shatter rock for removal by dredger, 1000ft of quay having been prepared. It is claimed that the construction is, economically, a South African record because of the hard rock at the foundations.

Our illustrations show the occasion in October, 1959, when the second blast was set off in the second stage of the operations, and the scene after the blast had subsided and the rubble had been cleared. On this occasion 25 tons of gelignite were used.

The writer is indebted to the South African Railways and Harbours administration and to Messrs. Olivier and Watson, East London, for the photographs reproduced.



Track recording trolley with the outrigger detector assemblies extended

Track Recording Trolleys

MECHANISATION of track maintenance on the South African Railways has taken another forward step with the acquisition of four self-propelled track recording trolleys. The machines which were supplied by Matisa Equipment, Ltd., Chertsey, England, and are the first of their kind in use on the South African Railways, are equipped for detecting and recording defects in the tracks, and they enable irregularities to be pin-pointed to within three to four sleepers. The trolley can operate in either direction and is staffed by a driver and an operator but has additional accommodation for inspection staff.

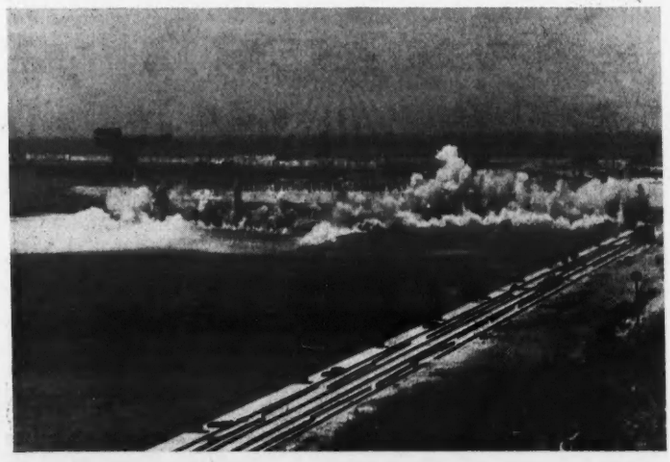
The vehicle, shown above, is of simple construction, carried on two axles and propelled by a 65 h.p. petrol engine. As it travels along the track, irregularities are detected by the combined movements of probes and wheel flanges carried on three sets of detector assemblies. One assembly is mounted between the axles of the vehicle and one at each end on bogies connected by outriggers. When surveying a track the vehicle is driven at a speed of up to 19 m.p.h., but when travelling at higher speeds between the working points, the outrigger assemblies are swung back and supported on the main body of the trolley while the detector assemblies are secured underneath the vehicle.

The detector assemblies are connected through wire cables and mechanical linkages to a series of pens on a recording instrument in the vehicle. This instrument continuously records the geometry of the track on a roll of transparent paper, the speed of movement of which is related to the speed of the vehicle. The recording can be reproduced by printing for distribution to the permanent way staff.

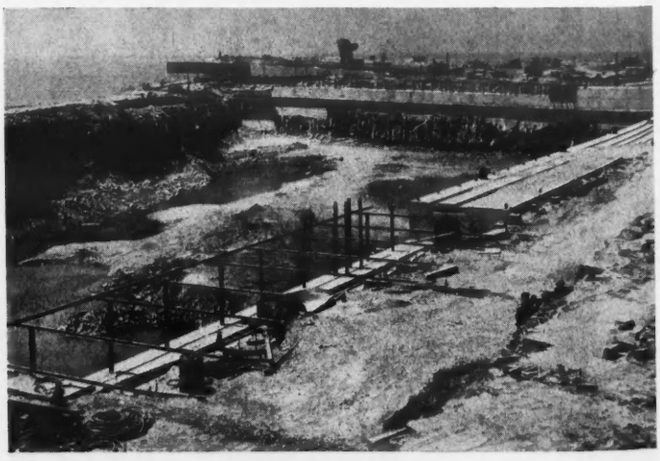
The function of the trolley is to record high and low points on both rails, versines (curvature) of both rails (this record of the curvature of each rail independently shows up poor alignment on straight track and irregular curvature on curved track), super-elevation or cant of the track, twist or skew, gauge variations, recording speed and mileage. As the vehicle passes salient features at the side of the track, such as, for example, mile posts, bridges and tunnels which can be used for identification purposes, the recorder operator presses a conveniently placed button to indicate their position on the graph.

The measurements of the high and low points on each rail are a dependent variable of the vertical displacement of the detector wheel of one of the axles on the car in relation to a reference plane formed by the two auxiliary trolleys. The radii of curves are shown by the continuous recording of the versines measured over a chord of 10m. This 10m is the distance between the feeler wheels of the outrigger trolleys at each end of the vehicle, and the versine is measured by the detector assembly in the centre of the recording car.

Rail cant is measured by displacement of a compensated pendulum, and to compensate for centrifugal force, which depends upon the speed of the vehicle, a correction table is provided for use with the value recorded on the chart. Skew is measured by the angle being produced between the two angles of the vehicle, and gauge variations by the two feeler wheels of the central assembly on the trolley.



Underwater blasting at East London for extensions to harbour



Area de-watered after blasting

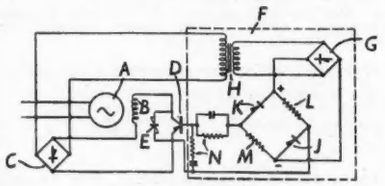
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRICAL ENGINEERING

831,524. March 15, 1956.—VOLTAGE REGULATOR CIRCUITS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Walter John Renaud Farmer.*)

This invention relates to control apparatus for regulating the voltage of an a.c. generator in which the excitation current is controlled by a transistor control device, the input to which is a function of the difference between the generator voltage and a reference voltage. The drawing shows one embodiment in which the transistor device controls the excitation current directly. In an a.c. generator *A*, the field winding *B* is supplied through a bridge rectifier *C* and a transformer (not shown) if necessary, from the output voltage of the generator. Connected in series with the field winding is the output circuit of a transistor *D* and connected across the transistor is a non-linear resistor *E*. Voltage sensitive circuit *F*

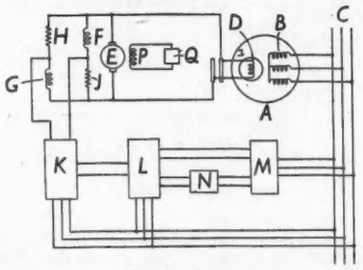


No. 831,524

comprises a bridge rectifier *G*, supplied, via a transformer *H* from the output of the a.c. generator, and connected to a comparator bridge circuit employing two Zener diodes *J* and *K* in one pair of opposite arms, and two resistances *L* and *M* in the other pair of arms. With the polarity of the d.c. as shown, the Zener diodes will maintain a constant voltage across them, which could be of the order of, say, 5V; this provides the reference voltage. Thus, when the bridge is balanced, the voltage across the resistors would also be 5V, and the total d.c. voltage connected to the bridge would be 10V. The output of the bridge is fed to a stabilising network *N* and thence to the transistor as shown. When the bridge is balanced, the voltages across the Zener diodes will equal the voltages across the resistors and the output voltage of the bridge will be zero, and consequently substantially no current will flow through the emitter-base circuit of the transistor. Should the generated voltage rise, however, the bridge becomes unbalanced and a current will flow in the emitter-base circuit of the transistor, in a direction to restore the generator voltage to its initial value.—*March* 30, 1960.

833,637. November 11, 1955.—AUTOMATIC VOLTAGE CONTROL, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventors: Sidney George Stubbs, Clifford Royle and Norman Harry Shaw.*)

This invention relates to an automatic voltage regulating system for a d.c. excited alternator, as in an aircraft. Referring to the drawing, the alternator *A* has an output winding *B* arranged to supply the busbars *C* and a field winding *D* supplied from a direct coupled exciter *E*. A self-excited field winding on the exciter is in two sections *F*, *G*, connected as two opposite arms of a bridge circuit, the other two arms consisting of resistors *H* and *J*. One diagonal of the bridge is connected across the exciter armature, whilst the other diagonal is supplied from a magnetic amplifier *K*. This is supplied from a further magnetic amplifier *L* having two input circuits; one circuit is supplied with a voltage dependent on alternator output voltage via one output winding of a transformer *M*—supplied from the busbars—whilst the other circuit is supplied from a substantially constant voltage source *N*, in turn supplied from another output winding on the transformer. The characteristics of the exciter *E* are such that, in the absence of any output from the magnetic amplifier *K*, the exciter will supply an abnormal exciting current to the alternator of a value at least one-and-a-half times that required at normal full load rating of the alternator. Under normal full load conditions, however, the magnetic amplifier *K* applies a voltage to the bridge circuit of a polarity such that the component of current through the exciter field winding due to this voltage opposes the current due to the exciter itself and is of a magnitude such that the excitation is reduced to the correct value for normal full load conditions on the alternator. It will thus be seen that, in the event of a substantial drop in alternator output voltage due, for example, to a short-circuit or heavy overload on the alternator, both the input to the magnetic amplifier *L* and the power supply to both magnetic amplifiers will fall to a very low value, with a consequent fall in the output of the magnetic amplifier *K*. This will result

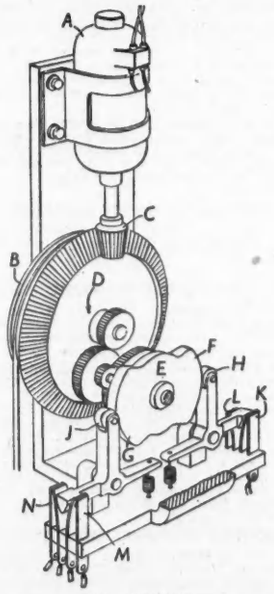


No. 833,637

in a fall in the opposing component of current through the exciter field winding and the exciter will therefore build up to substantially its full output. The output current of the alternator will therefore be maintained at a value sufficient to operate any protective devices in the load circuit and thereby clear the fault. A separately excited bias field winding *P* on the exciter is supplied from a d.c. bias source *Q* and is arranged to assist the self-excited winding. The bias winding functions to prevent permanent reversal of the self-excited field arising from a heavy load shedding transient, the no load flux being small compared with such a transient. Under normal load conditions any variation of alternator output voltage will result in a variation of input to the magnetic amplifier *L* with a resulting variation of the opposing component of current in the exciter field windings in a sense to correct the variation of alternator output voltage. In cases where sufficient amplification can be obtained in one magnetic amplifier, the magnetic amplifier *K* may be omitted.—*April* 27, 1960.

833,532. March 28, 1957.—ELECTRICAL WINDING AND HAULAGE EQUIPMENT, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Leslie Carter Ludbrook.*)

A particular case of electric haulage and winding arises in equipment for raising and lowering the control rods of a nuclear reactor. In such equipment



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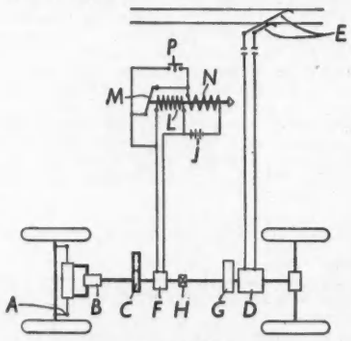
it is necessary to allow all the rods to fall rapidly under emergency conditions known as "scram," and to reduce their speed to a safe value before impact. According to the present invention, electrical winding and haulage equipment comprises an electric winding motor having a permanent magnet rotor and a polyphase stator winding, a first set of resistances connected permanently across the stator windings to provide dynamic braking when running free in the downward direction and means for successively connecting additional sets of resistances across the windings to provide additional braking when the load approaches the downward end of its travel. The drawing shows apparatus which could be attached to the winding motor shaft in order to operate the switches when the load has reached predetermined points in its downward travel. Motor *A* drives a winding drum *B* through a bevel drive *C*. The winding drum is also coupled through a gear train *D* with a double cam *E*. The cam has two cam surfaces *F* and *G* which operate on two cam followers *H* and *J* respectively. These cam followers are pivotally mounted and the follower *H* actuates double-pole switches *K*, *L*, whilst follower *J* actuates switches *M* and *N*. These switches connect the resistances across the stator windings. Normal winding in either direction is carried out by connecting the electrical supply to the motor stator phase windings in the appropriate sense according to the direction of wind. Under conditions of emergency the supply is disconnected and the load, e.g. control rod, allowed to fall freely. Initially, only the two permanent resistances are connected in the circuit and the speed of travel rises to a high, steady value, depending on their value, and any external friction effects. At a later stage, switches *K* and *L* are closed in the manner described above and two further resistances are connected into the circuit. The braking effect is therefore increased and the speed drops accordingly. Finally, switches *M* and *N* are closed to bring in two more resistances. This reduces the speed even further and eventually the bottom limit of travel is reached at a very low speed. Mechanical braking can in some cases be applied to bring the load finally to rest. The motor is described in the specification as having a two-phase stator but it can have any number of phase windings in its stator and braking resistances may be connected across each of these windings.—*April* 27, 1960.

ELECTRIC TRACTION

833,791. May 30, 1956.—TROLLEYBUS AUXILIARIES, Zahnradfabrik Friedrichshafen Aktiengesellschaft, Friedrichshafen-on-the-Bodensee, Germany.

This invention relates to the drive of a pump in a trolleybus for operating power-assisted steering gear. In the drawing the chassis of a trolleybus is fitted with a steering linkage *A* actuated by hydraulic steering gear *B*. The latter is supplied with oil under pressure by the pump *C*. The vehicle is driven by traction motor *D* which is supplied from an overhead network through the trolley arms *E*. The motor *A* drives the dynamo *F* of the vehicle through a step-up gear *G* and a freewheel clutch *H*. The dynamo is connected with the pump *C*. Under normal driving conditions the pump is driven by the traction motor at a geared speed, and the dynamo charges the



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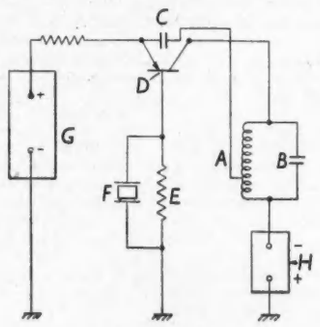
battery *J* through the interposition of a reverse current switch of normal type. The coil *L* of the reverse current switch is connected to the terminals of the dynamo and closes the switch *M* as soon as the dynamo exceeds a predetermined speed. A charging current then flows into the battery circuit. This charging current also passes through the coil *N* which is so wound that it assists the action of the coil *L* and maintains the switch closed. When the speed of the dynamo falls below a predetermined limit the switch *M* is opened and no current flows from the battery back to the dynamo. Thus, under

normal conditions, the pump is driven by the traction motor through the step-up gear *G*. The ratio of the gear is determined so that, even at the slowest travelling speeds, the pump still delivers sufficient hydraulic oil to enable the driver to operate the steering with ease. With this arrangement it is possible to travel under normal conditions even at slow speeds with no trouble and no inconvenience to the driver. During switching over manœuvres at particularly slow speeds, especially when starting up, the driver operates the switch *P* by means of which the dynamo is directly connected with the battery, by-passing the regulator cut-out. In this way an adequate supply of oil is ensured, even with stationary vehicles and at the slowest speeds, to maintain the servo-steering.—*April* 27, 1960.

ELECTRONICS

833,703. February 14, 1956.—TRANSISTOR OSCILLATORS, Compagnie Française Thomson-Houston, 173, Boulevard Haussmann, Paris (8e), France.

As is well known, it is possible to obtain very high frequency stability with a valve oscillator which utilises a piezo-electric quartz crystal as the stabilising element. If an analogous circuit is constructed employing a transistor in place of the valve it is found that the frequency stability of such a circuit is considerably reduced. The cause of this defect is the variation in the parameters of the transistor as a function of changes in temperature and supply voltages. According to the present invention, an



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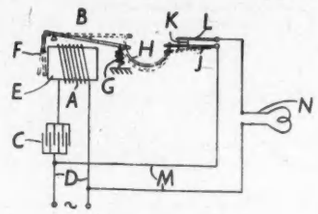
electronic oscillator comprises a transistor together with a positive feedback circuit tending to sustain oscillations and a frequency selective negative feedback circuit. Referring to the drawing, the parallel resonant circuit formed by components *A* and *B* will tend to oscillate at its resonant frequency and feed back a sufficient portion of its energy via capacitor *C* to the input of transistor *D* to sustain its oscillations. However, resistance *E* in the base connection to the transistor provides negative feedback to prevent oscillation at all frequencies except at the resonant frequency of crystal *F* which, when resonating, acts to short-circuit resistance *E*. Thus it can be seen that the frequency at which the circuit oscillates will be rigorously controlled by the oscillatory frequency of the crystal. Furthermore, neither the emitter-base capacity nor the collector-base capacity of the transistor appears in parallel with the crystal and hence these parameters cannot modify its resonant frequency. The oscillatory frequency of the circuit is thus insensitive to variations of temperature or supply voltage. Numerous variations are possible without departing from the principles of the invention, such as the use of a n-p-n transistor with appropriate changes in the polarity of polarising sources *G* and *H*; or the replacement of capacitive coupling between emitter and collector by another form such as a mutual inductance.—*April* 27, 1960.

833,686. December 28, 1955.—STREET LIGHTING CONTROL, General Electric Company, Schenectady 5, State of New York, United States of America.

This invention relates to photoconductive control circuits particularly suited for turning street lights on and off at desired ambient light levels, and dispenses with the need in photoemissive systems to rectify the supply in order to eliminate relay chatter. Referring to the drawing, the operating winding *A* of a snap-action relay *B* is connected directly in series circuit with a photoconductor *C* across supply conductors *D*, which are directly connectible with an a.c. source of supply of commercial voltage. The winding of the relay encircles its core structure *E* which, depending on the energisation of the winding, attracts an armature *F* which is biased by a spring *G* to the full-line position shown in the drawing. The relay armature is connected through an over-centre snap-action mechanism comprising a bow spring *H*, to a flexible support member *J* for one of the contacts *K* of a switch whose other contact is mounted on a support member *L*. When armature *F* of the relay is in the full-line position illustrated, the bow spring and contact support *J* are also in their full line positions illustrated. When the relay is energised the armature moves to its dotted line position and the bow spring passes through a dead centre position to move switch member *J* to its dotted line position and open contacts *K* of the switch. When the relay



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winding is de-energised, the parts of the relay return to their full-line positions, again closing the contacts of the switch. The contacts of this snap-actuated switch complete the connection of the lamp circuit across the alternating current supply conductors. One or more lamps *N* are connected in multiple or series circuit relation with one another for energisation through this lamp circuit from the source of supply. The particular over-centre snap-action switch mechanism represented in the drawing is but one of many forms of such mechanism which may be employed.—*April* 27, 1960.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, May 20.—COVENTRY AND DISTRICT BRANCH: E.M.E.B. Sports and Social Club, Merrick Lodge, Sandy Lane, Coventry, Annual General Meeting, 7.30 p.m.

To-day to Sun., May 20 *to* 22.—NATIONAL EVENT: Royal Hotel, Scarborough, Annual Conference.

Mon., May 23.—NORTH WEST LONDON BRANCH: The Compass Hotel, Watford, "Impact of the N.I.C.E.I.C.," E. J. Sutton 8.15 p.m.

Tues., May 24.—EAST KENT BRANCH: Clarendon Hotel, Broadstairs, "Earth Leakage Protection of Domestic and Similar Installations," J. A. Robbins, 8 p.m. ★ NEWCASTLE UPON TYNE AND DISTRICT BRANCH: Crown Hotel, Clayton Street, Newcastle upon Tyne, Annual General Meeting, 7.30 p.m.

Wed., May 25.—WOLVERHAMPTON AND DISTRICT BRANCH: Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, Annual General Meeting, 7 p.m.

Thurs., May 26.—BRIGHTON, HOVE AND DISTRICT BRANCH: New Imperial Hotel, First Avenue, Hove, "Variable Speed A.C. Motors," 7.30 p.m. ★ SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Electricity as Supplied to the Printing Trade," S. C. Bellringer, 8 p.m. ★ SOUTH LONDON BRANCH: Greyhound Hotel, High Street, Croydon, Surrey, Annual General Meeting, 7.15 p.m.

Fri., May 27.—ALDERSHOT AND DISTRICTS BRANCH: Queens Hotel, South Farnborough, Hants, Annual General Meeting, 7.30 p.m. ★ LIVERPOOL AND DISTRICT BRANCH: Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, Annual General Meeting, 6.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Wed., May 25.—Savoy Hotel, London, W.C.2, One-day conference on "Management Consultants in Industry and Commerce," 9.30 a.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, May 20.—STUDENTS' MEETING: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Servomechanisms and Electronics Engineers—the Present and the Future," M. James, 7 p.m.

Wed., May 25.—Gustav Tuck Theatre, University College, London, Symposium on "Stable Frequency Generation"; "The Problem of Frequency Synthesis," H. J. Finden; "The Change-of-State Crystal Oven," D. J. Fewings; "The Application of Counting Techniques to the Control of High Stability H.F. Oscillators," R. P. Thatte; "A Transistorised Frequency Synthesizer," G. Husson and B. N. Sherman; "The Synthesis of High Purity Oscillations Suitable for Single Sideband Receivers," P. S. Carnt and E. Ribchester, and "An Airborne Frequency Generating Unit for the H.F. Communication Band," G. E. Smythe, 3 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., May 24.—SCOTTISH REGION: Royal Hotel, 5, Union Street, Dundee, Discussion on "Clean Air and Industry," 10.30 a.m., and a Discussion on "Water Treatment for Industrial Boiler Plant," opened by D. S. Kerr, 2 p.m. ★ Engineers' Club, Albert Square, Manchester, Open Discussion on "Combustion Problems," opened by the Right Worshipful the Lord Mayor of Manchester, Alderman Harold Quinney, 10.30 a.m. and 2.30 p.m.

INSTITUTE OF FUEL

Mon., May 23.—Institution of Civil Engineers, Great George Street, London, S.W.1, "Recommendations on Heights for New Industrial Chimneys," G. Nonhebel, 5.30 p.m.

INSTITUTE OF PETROLEUM

Wed., to Sun., May 25 *to* 29.—Summer Meeting at Bournemouth, Theme, "Planning for Productivity in the Petroleum Industry."

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., May 31.—METROPOLITAN AREA: Visit to the brewery of Watney Combe Reid and Co., Ltd., 10 a.m.

INSTITUTION OF CHEMICAL ENGINEERS

Fri., May 27.—CHEMICAL ENGINEERING RESEARCH COLLOQUIA: Lecture Theatre 105, Imperial College of Science and Technology, Department of Chemical Engineering, Prince Consort Road, London, S.W.7, "Heat Transfer to Liquid Fluidised Beds and to Coarse Suspensions Flowing in a Vertical Pipe," J. W. Smith, 3.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 24.—Great George Street, Westminster, London, S.W.1, "The New Highway Bridges Across the River Tigris in Iraq at Amara and Kut," W. E. Gelson and G. A. Plank, and "The Analysis of Steel Decks with Special Reference to the Highway Bridges at Amara and Kut, Iraq," B. Farago and W. W. L. Chan, 5.30 p.m.

Thurs., May 26.—Great George Street, Westminster, London, S.W.1, Films, "London to Birmingham Motorway" and "The Changing Face of Lincoln," 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day to Mon., May 20 *to* 23.—WESTERN CENTRE: Abernant Lake Hotel, Llanwrtyd Wells, Summer Meeting.

Wed., May 25.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, Discussion on "New Semiconductor Devices and Their Possible Applications," opened by A. F. Gibson and G. King, 5.30 p.m.

Thurs., May 26.—SCOTTISH CENTRE: Electrical Engineering Department, Queen's College, Dundee, Annual General Meeting, 7 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Fri., May 27.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Joint Meeting with the Aluminium Development Association, Symposium on "The Use of Aluminium in Railway Rolling Stock," 10 a.m. and 2.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day to Sun., May 20 *to* 22.—EASTERN GRADUATES' SECTION: Annual works visit to SIMCA Factory at Poissy and Institut Français de Pétrole at Reuil-Malmaison, near Paris.

Tues., May 24.—LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting; Election of the Committee for the 1960-61 Session, and "The Mechanical Aspects of Fractional Horsepower Motors," P. G. Edkins, 6.30 p.m. ★ MIDLAND GRADUATES' SECTION: Evening Visit to Stewarts and Lloyds, Ltd., Erdington, Birmingham.

Wed., May 25.—1, Birdcage Walk, Westminster, London, S.W.1, Special Meeting, 6 p.m. ★ EAST MIDLANDS GRADUATES' SECTION: Whole-day visit to Stewarts and Lloyds, Ltd., Corby Works.

Thurs., May 26.—SCOTTISH BRANCH: Evening visit to L. Sterne and Co., Ltd., Kelvin Avenue, Hillington.

Fri., May 27.—SCOTTISH GRADUATES' SECTION: Joint visit with the Northern Ireland Graduates' Section to the steel works of Colvilles, Ltd., 9.45 a.m.

Sat., May 28.—SOUTHERN BRANCH: Visit to the Havant Pumping Station, 2.30 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., May 24.—S. WALES BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, "Controlled Maintenance," G. E. Halter, 7.30 p.m.

Thurs., May 26.—MERSEYSIDE AND NORTH WALES BRANCH: Exchange Hotel, Liverpool, "Packaging and Container Engineering," E. Evans, 7.15 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., June 1.—1959 GEORGE BRAY MEMORIAL LECTURE: Grand Council Chamber, The Federation of British Industries, 21, Tothill Street, London, S.W.1, "The Packaging of Engineering Products," C. H. Bulmer, 6.30 p.m.

INSTITUTION OF PROFESSIONAL CIVIL SERVANTS

Mon. to Wed., May 23 *to* 25.—Winter Garden, Eastbourne, Sussex, Annual Delegate Conference.

PLASTICS INSTITUTE

To-day to Sun., May 20 *to* 22.—Institute Visit to the Midlands Section.

ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY

To-day, May 20.—Department of Mechanical, Civil and Chemical Engineering, Glasgow, C.1, Symposium on "Nuclear Reactor Containment Buildings and Pressure Vessels."

ROYAL INSTITUTION OF GREAT BRITAIN

Wed., May 25.—21, Albemarle Street, London, W.1, "Luminescence—The Cold Light of Physics," G. F. J. Garlick, 9 p.m.

ROYAL INSTITUTION OF NAVAL ARCHITECTS

To-day, May 20.—Royal Festival Hall, London, S.E.1, Centenary Meeting.

ROYAL SOCIETY OF ARTS

Mon., May 23.—CANTOR LECTURE: John Adam Street, Adelphi, London, W.C.2, "Energy—The Retail Distribution of Electricity," C. Robertson King, 6 p.m.

Wed., May 25.—John Adam Street, Adelphi, London, W.C.2, "Problems and Prospects of Air Transport," P. G. Masefield, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Wed., May 25.—7TH ORDINARY MEETING: London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "Decision Making in the Steel Industry," K. D. Tocher and A. Muir, 5.15 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., May 24.—Manson House, 26, Portland Place, London, W.1, Annual General Meeting, 6 p.m., Presidential Address, R. S. Medlock, 7 p.m.

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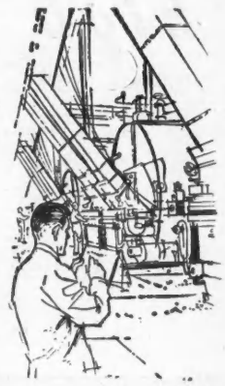

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An overall average efficiency of 72-75% can be easily maintained, although under test conditions we have recorded efficiencies of 80%.

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Our emergency stocks of coal are relatively small. We prefer to operate on a direct supply basis from colliery to boilerhouse for more or less immediate use. This would not suit every firm, but in our special circumstances I am perfectly satisfied that deliveries are reliable enough to make this system dependable, and the possibility of an emergency arising out of failure of supply is very remote. We have operated this way for three years now without any trouble at all and will continue to do so in the future.

Raleigh's decision to use coal is based on economics. We want maximum reliability at the lowest possible cost—and I'm happy to say that with coal that's exactly what we get."

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Total capacity:	74,400 lbs. of steam per hour
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Steam temperature:	324°F.
Annual fuel consumption (*all boilerhouses*):	22,300 tons of coal

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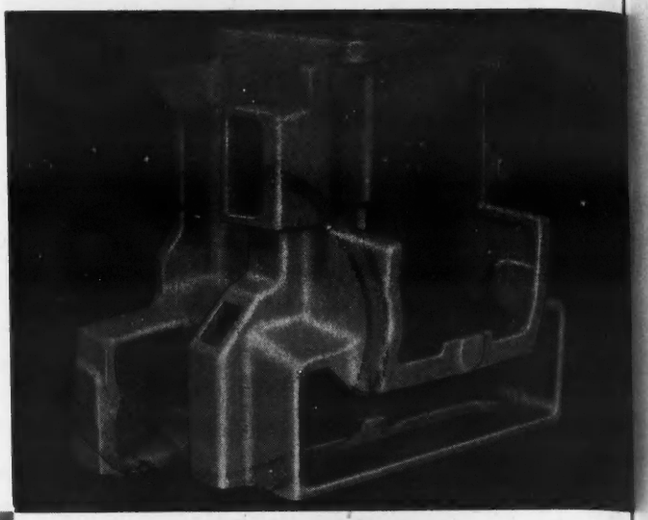

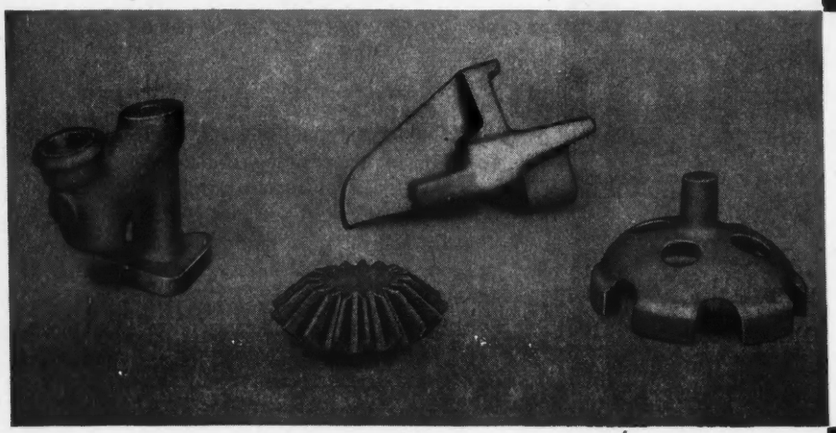

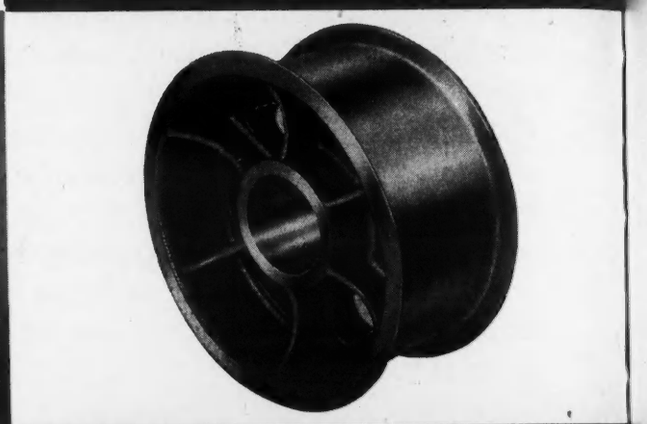

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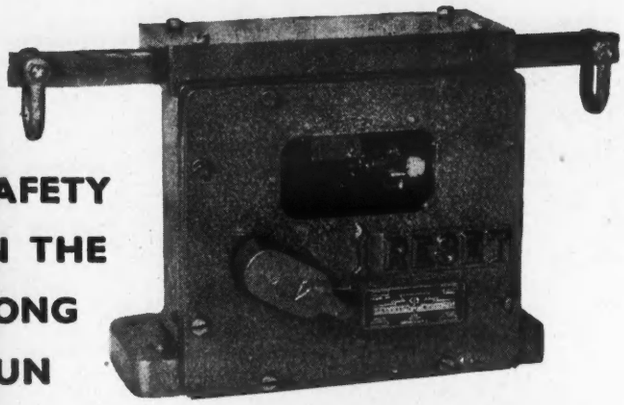

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Designed specially for use with conveyors and similar equipment, where long runs of machinery are in use, this safety device stops the driving motor (or applies a brake), at a touch of the trip wire. You owe it to yourself and your employees to fit this infallible safety device.

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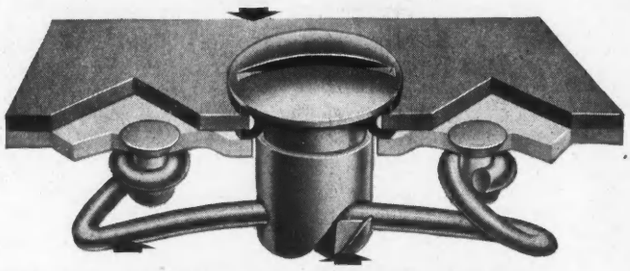
The locked position. The Dzus Fastener is instantly unlocked by a quarter turn anti-clockwise.



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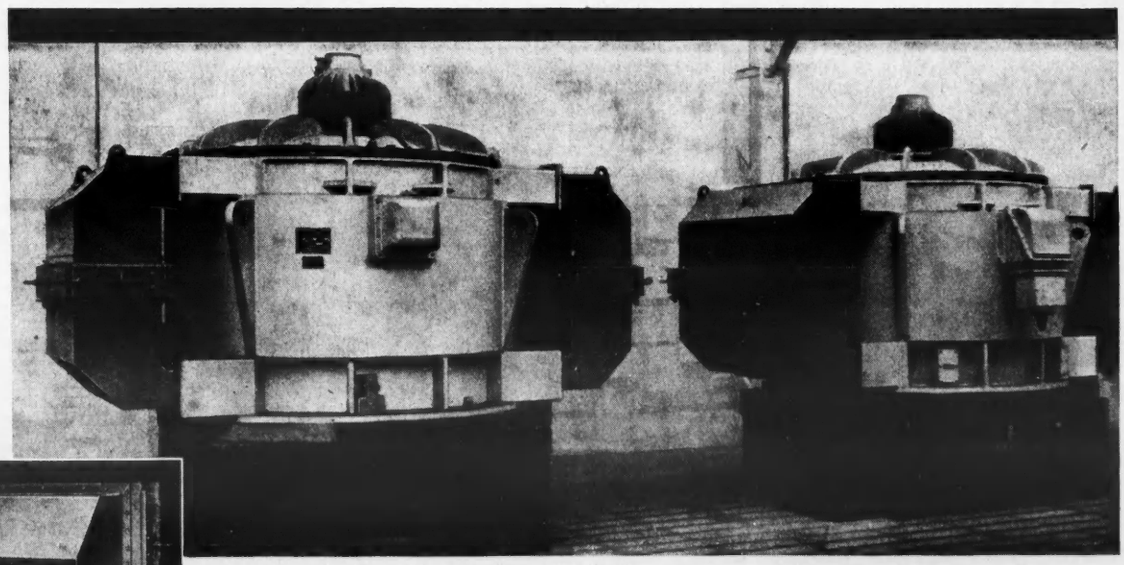
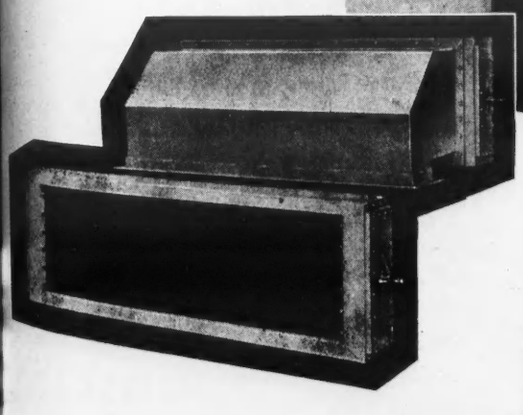


Right: 2 (of 8) 1600 h.p. induction motors. Vertical spindle, closed air circuit type with water coolers by Spiral Tube. For pump drives, Brooklyn Pumping Station, Melbourne.

Photograph by courtesy of Laurence Scott & Electromotors Ltd., Norwich.



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Over many years the company's technicians have progressively developed special cooling equipment in conjunction with the Electrical Engineering Industry.

The extensive knowledge gained thereby ensures the successful solution of all cooling problems. For most installations either water-cooled or air-cooled equipment is used, the usual Alternator or Motor Cooler is water-cooled, whilst for Transformer Cooling both water and air-cooled designs are in use.

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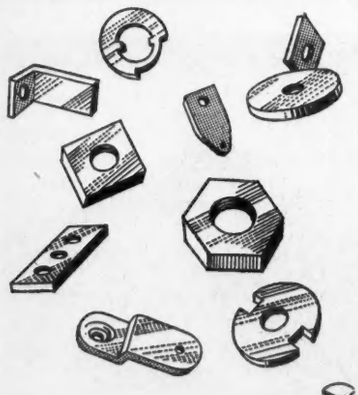

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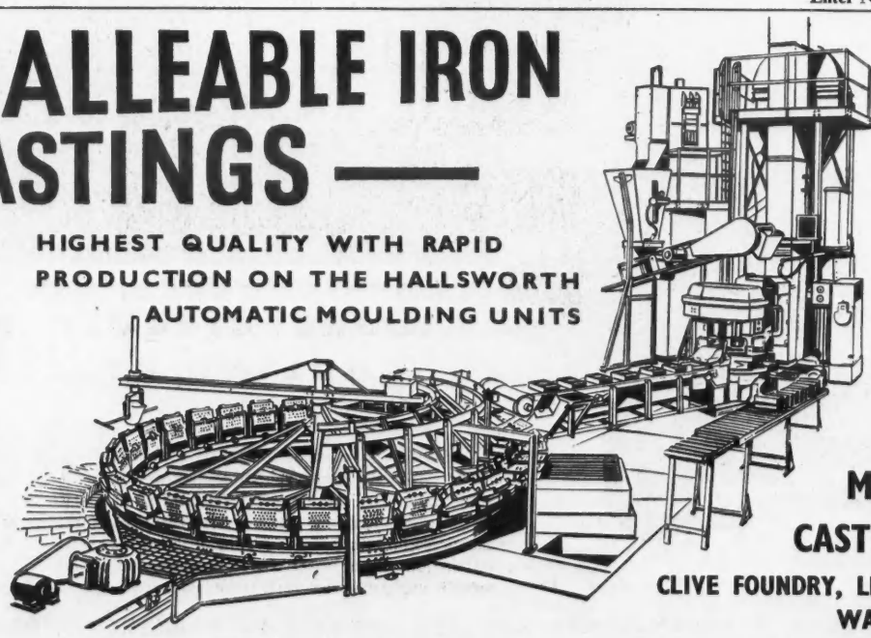

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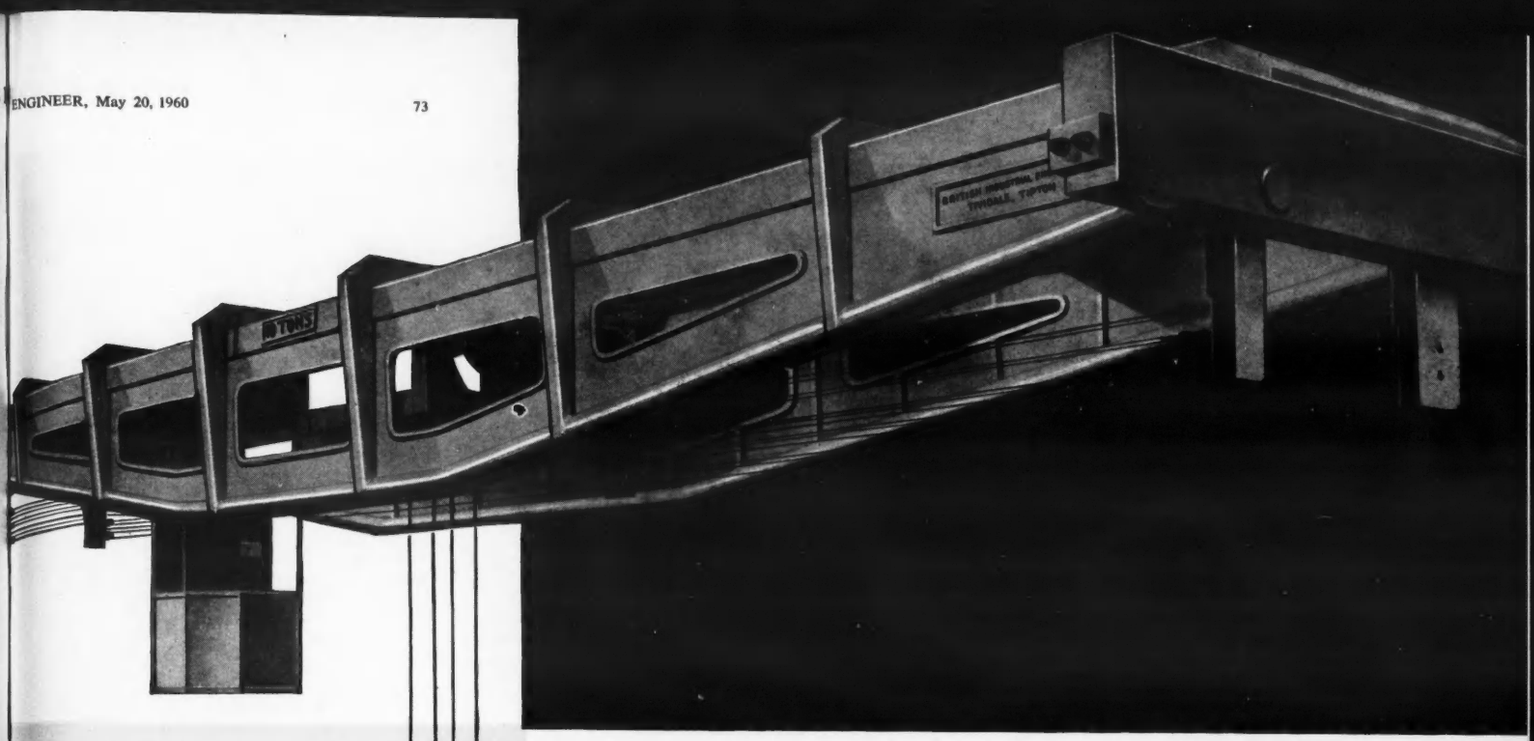

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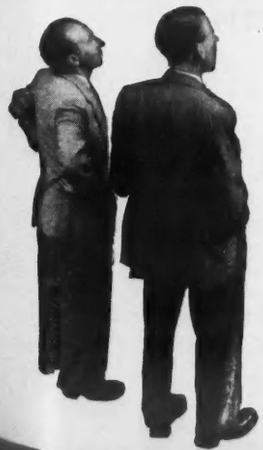

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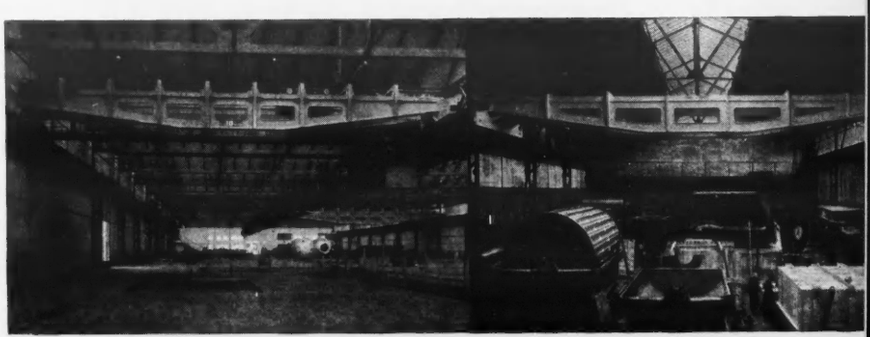

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NEOPRENE—a multi-purpose elastomer in manufacture since 1932

This elastomer has excellent resistance to oil, grease and most chemicals. It resists abrasion, cutting, chipping and flex cracking. In addition, it withstands sunlight, weathering and ozone.

Du Pont neoprene is ideal in cable jacketing, adhesives, colliery, conveyor and transmission belts, and in hose for oil and chemicals.

HYPALON—an elastomer with outstanding ozone and chemical resistance

Hypalon* is *completely* ozone-proof and is one of the few elastomers that can be compounded in an unlimited range of stable colours. It shows outstanding resistance to strong oxidising chemicals, such as concentrated sulphuric and chromic acids; and it withstands heat (at temperatures up to over 300°F.), abrasion, sunlight and weathering.

Du Pont Hypalon is ideal in coloured jacketing for wire and cable, coated fabrics, in protective and decorative coatings, for tank linings to hold oxidizing chemicals, hot materials belting, and white sidewalls for tyres.

VITON—a fluoroelastomer unsurpassed in fluid and heat resistance

This elastomer is unequalled for service in oils, solvents and chemicals at over 400°F., and resists most of the new fuels and lubricants used in jet aircraft. With its strong resistance to compression set, even at high temperatures, Viton* is ideal for gaskets subjected to heat.

Vulcanizates of Viton in any hardness of from 60 to 95 durometer, demonstrate a tensile strength, at room temperature, of up to 3000 psi., and ultimate elongation of up to 400%. Combining these properties with a high resistance to oxygen and weathering, Viton is an ideal material for precision seals, valve seats, diaphragms and coated fabrics.

In certain services, Viton has given satisfactory performance as low as —65°F.

	NEOPRENE	HYPALON	VITON
Hardness Range	40 to 95 Shore A	40 to 95 Shore A	60 to 95 Shore A
Tensile Strength	over 3000 psi	over 3000 psi	over 2000 psi
Temperature Range	−60°F. to +250°F.	−60°F. to +350°F.	−40°F. to 600°F.
Adhesion to Fabrics	Excellent	Good	Good to Excellent
Adhesion to Metals	Excellent	Excellent	Good to Excellent
Chemical Resistance	Good	Good to Excellent	Excellent
Compression Set Resistance	Fair to Good	Fair	Very Good
Ozone Resistance	Excellent	Outstanding	Outstanding
Flame Resistance	Good	Good	Good
Sunlight and Weather Resistance	Very Good	Outstanding	Very Good
Abrasion Resistance	Excellent	Excellent	Good
Oil Resistance	Good	Good to Excellent	Excellent

*Hypalon and Viton are both registered trade marks of Du Pont elastomers.

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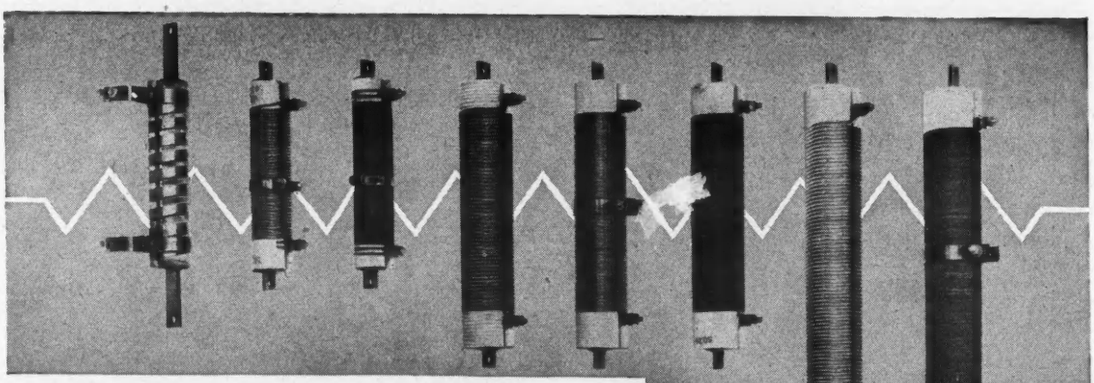
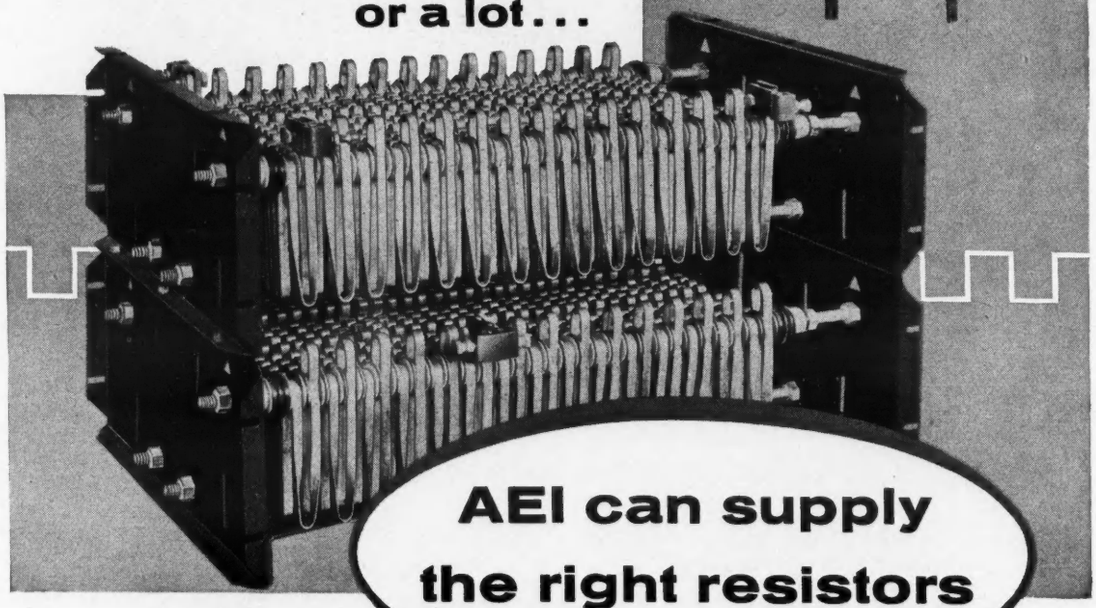


Whether you need a little

or a lot...



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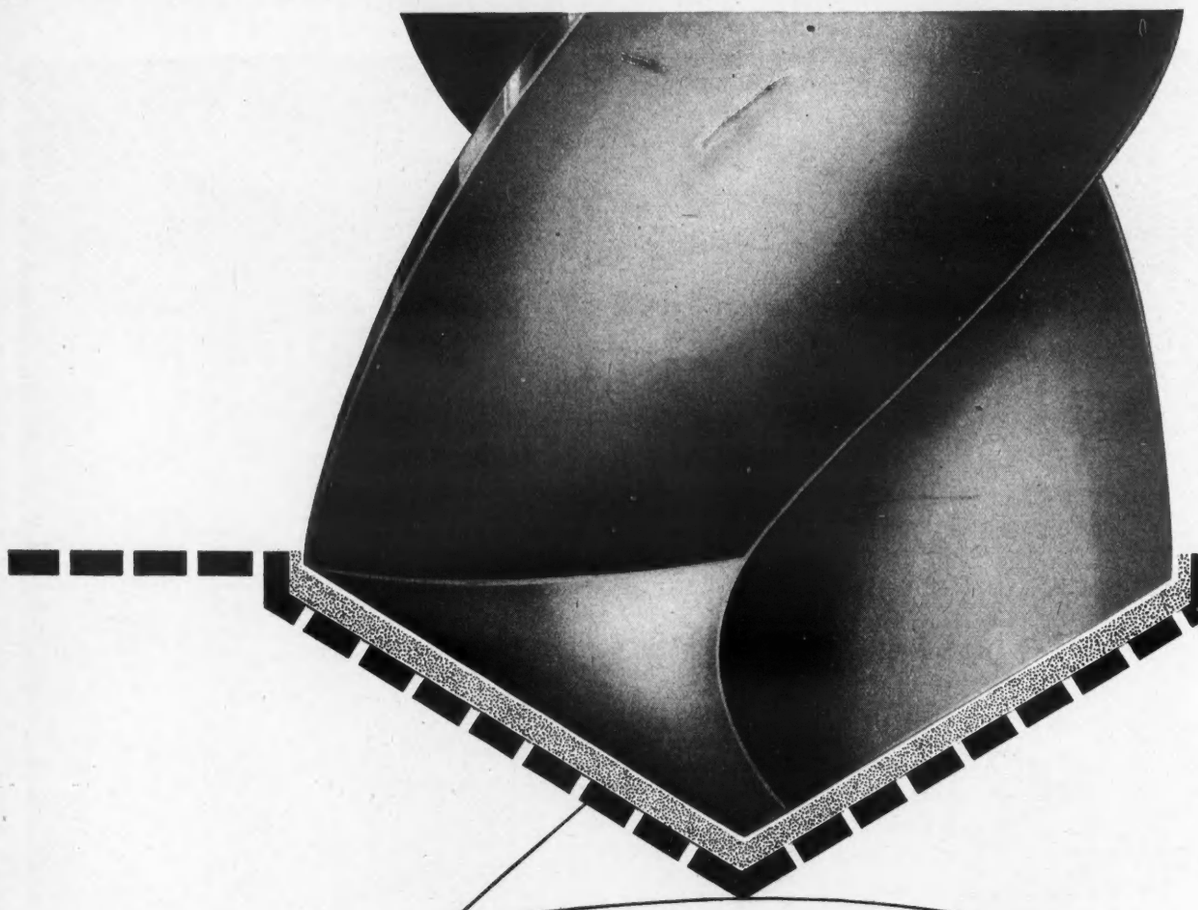

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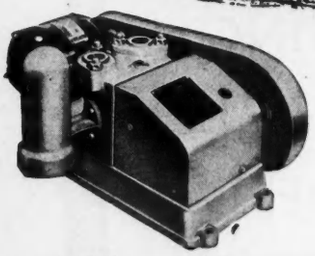

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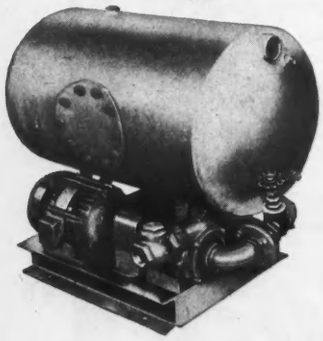

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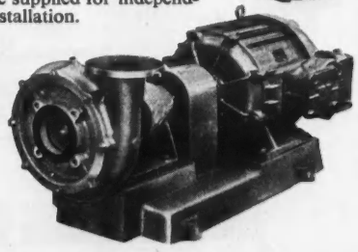

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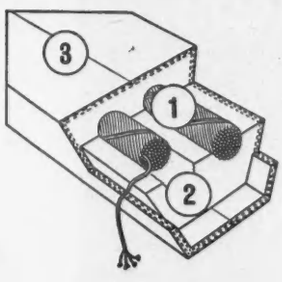

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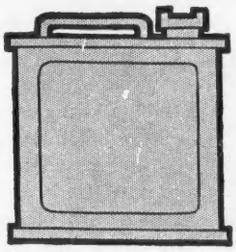
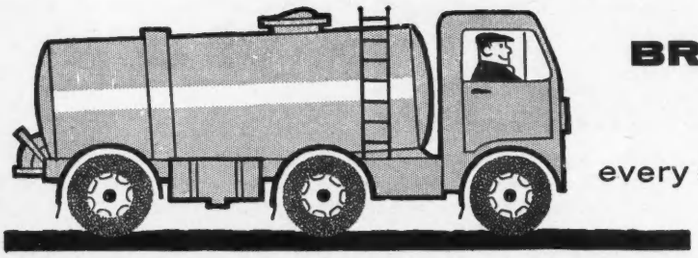


From a can of

PETROL

to a tanker of

TAR



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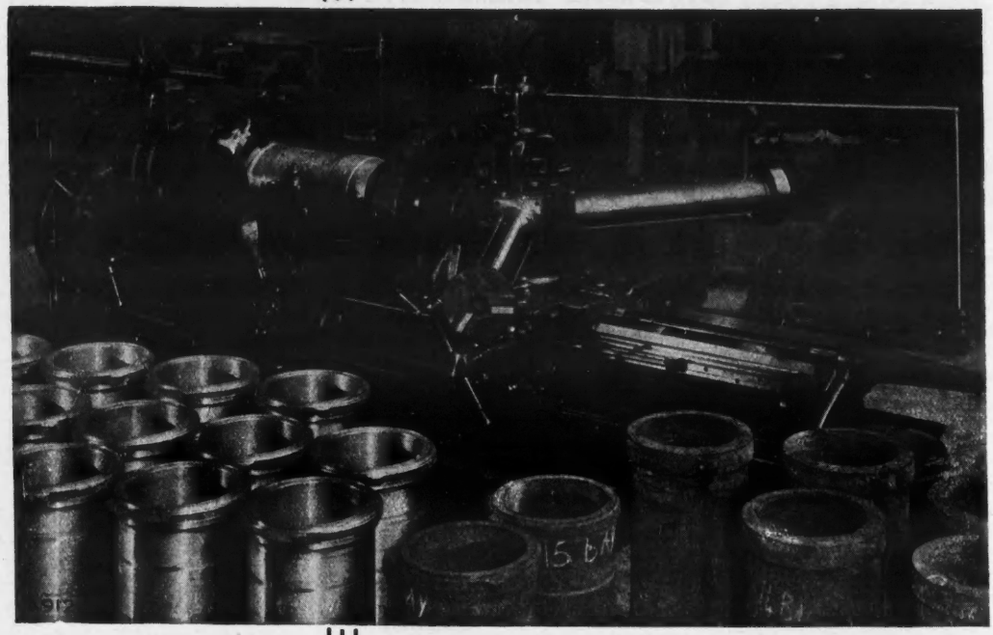
for Heavy Turret Lathe Work the HERBERT No. 14/36 Combination Turret Lathe



With a swing of 36in. and a drive motor of 50 h.p. it has all the advantages common to all sizes of Herbert Capstan and Turret Lathes—the power, speeds and rigidity to use carbide tools to full advantage, ease of setting up which makes for economical machining of one or two similar components, fast cutting times, high and consistent accuracy and excellent finish. Thirty-two speeds, 4 to 480 r.p.m. Sixteen reversible automatic sliding and surfacing feeds to saddle. Quick-power traverse to both motions. Chasing mechanism. Sixteen automatic feeds and quick-power traverse to turret slide. Hole through spindle, 8½in.

A Herbert No. 14/36 Combination Turret Lathe, with special tooling for machining cylinder engine liners, installed in the Rugby Works of the English Electric Company. Machined in a total time of 5 hours, four operations. External diameters are held to ±0·001in., bore parallel, concentricity and ovality to ±0·002in.

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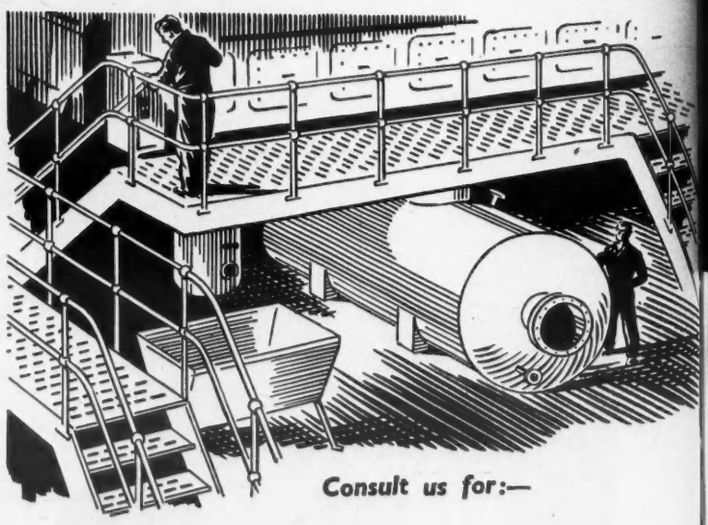

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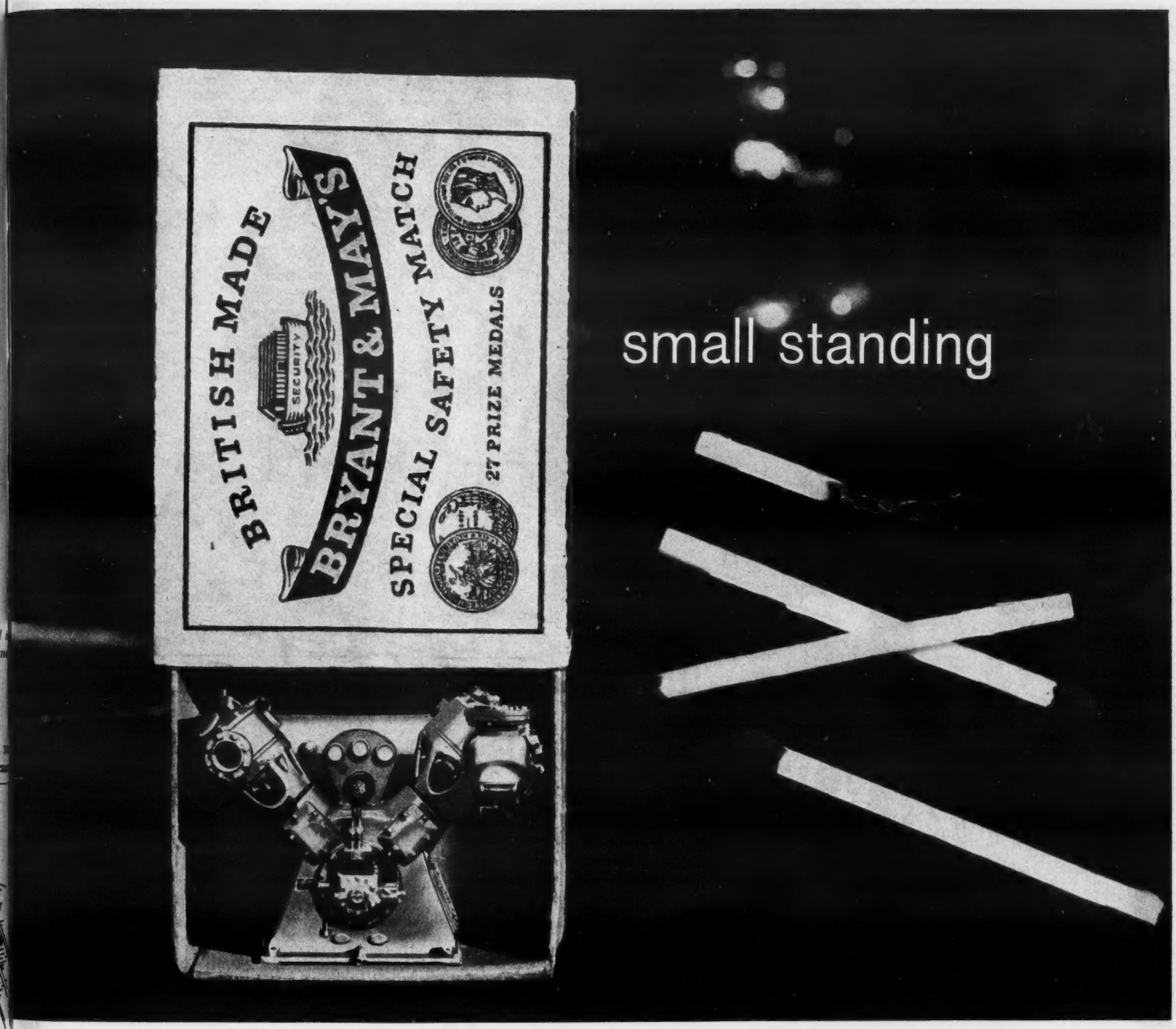

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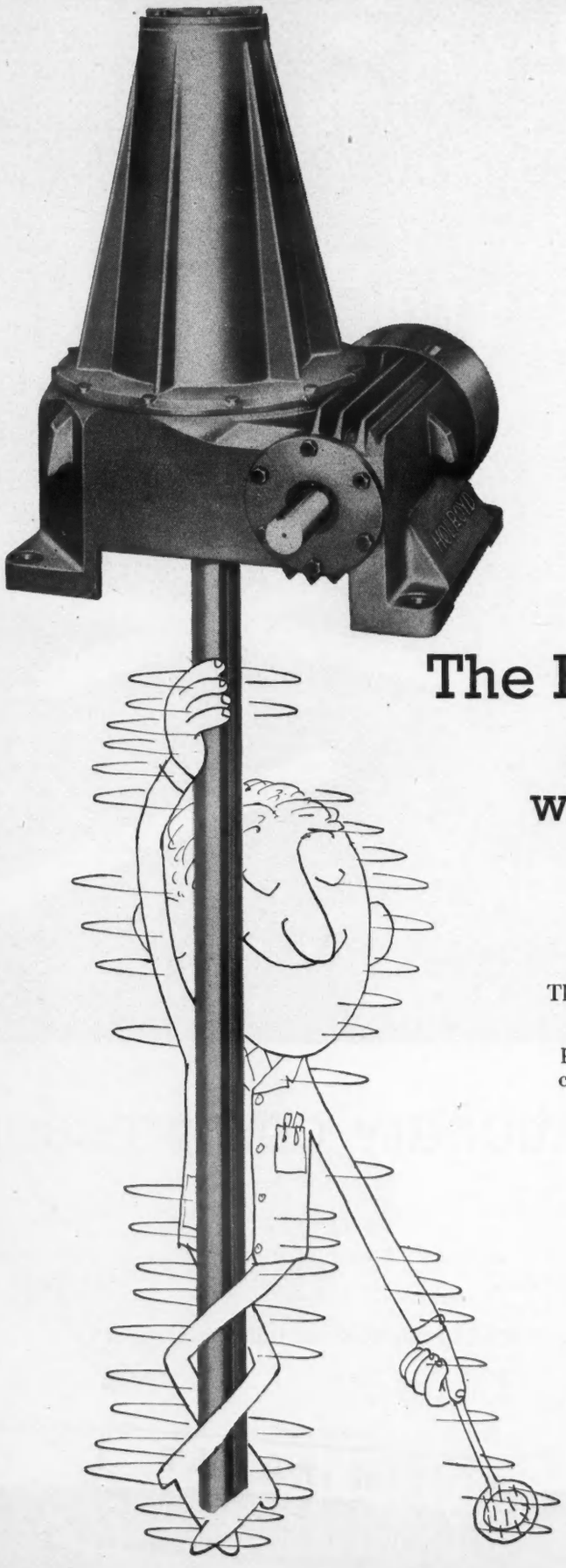

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holds the shaft steady while you stir things up

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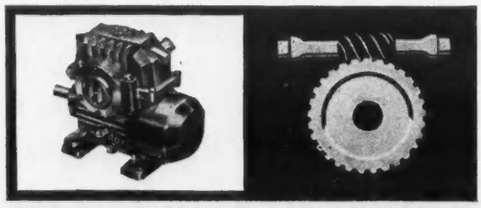

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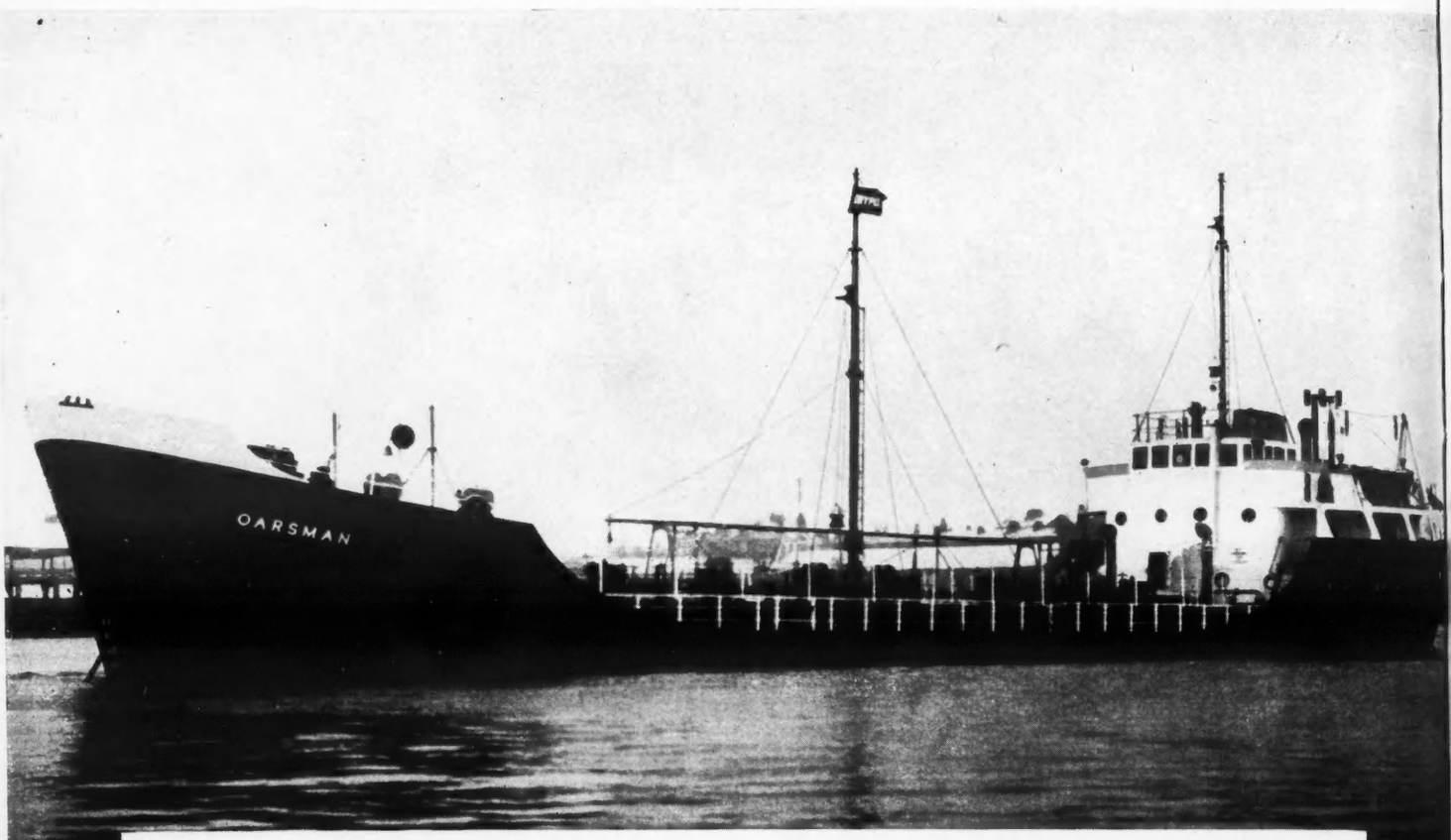

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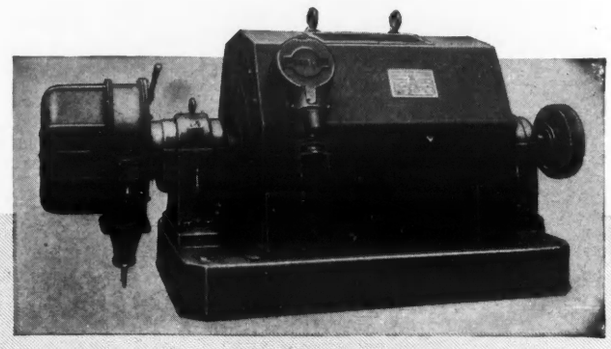

850 B.H.P. 3,300 volts, 1485 r.p.m. slip-ring motor for driving a crude oil pump at an oil depot in Scotland.

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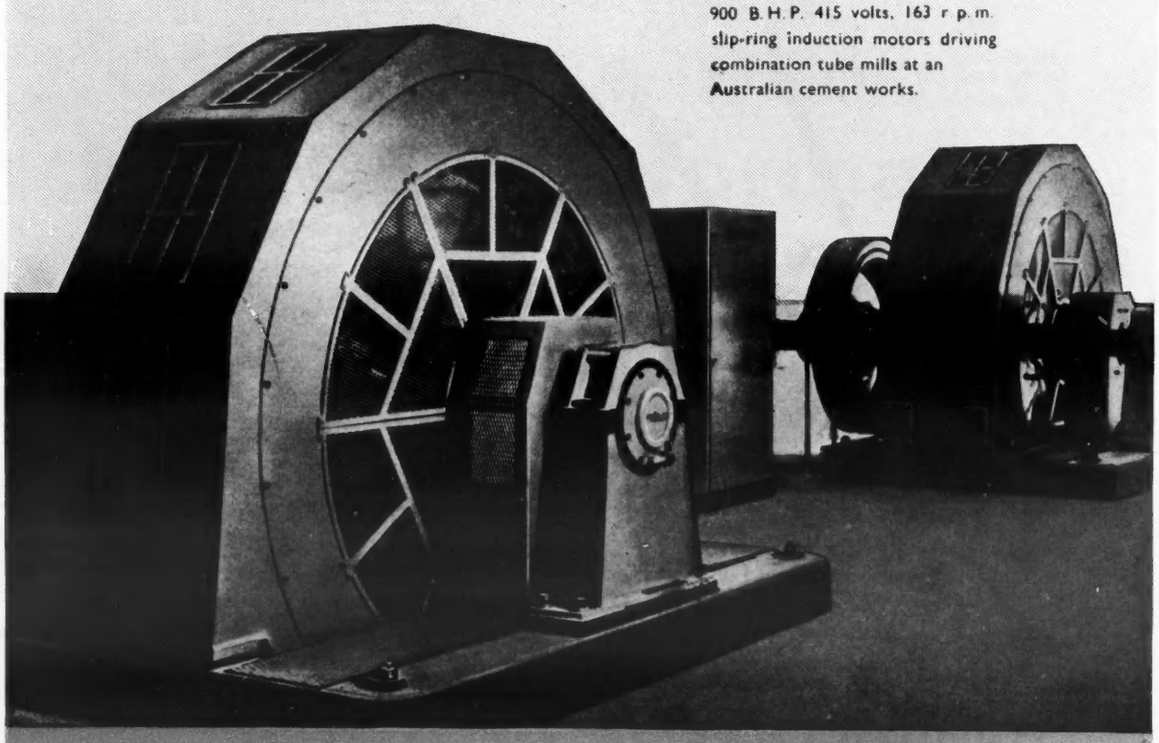

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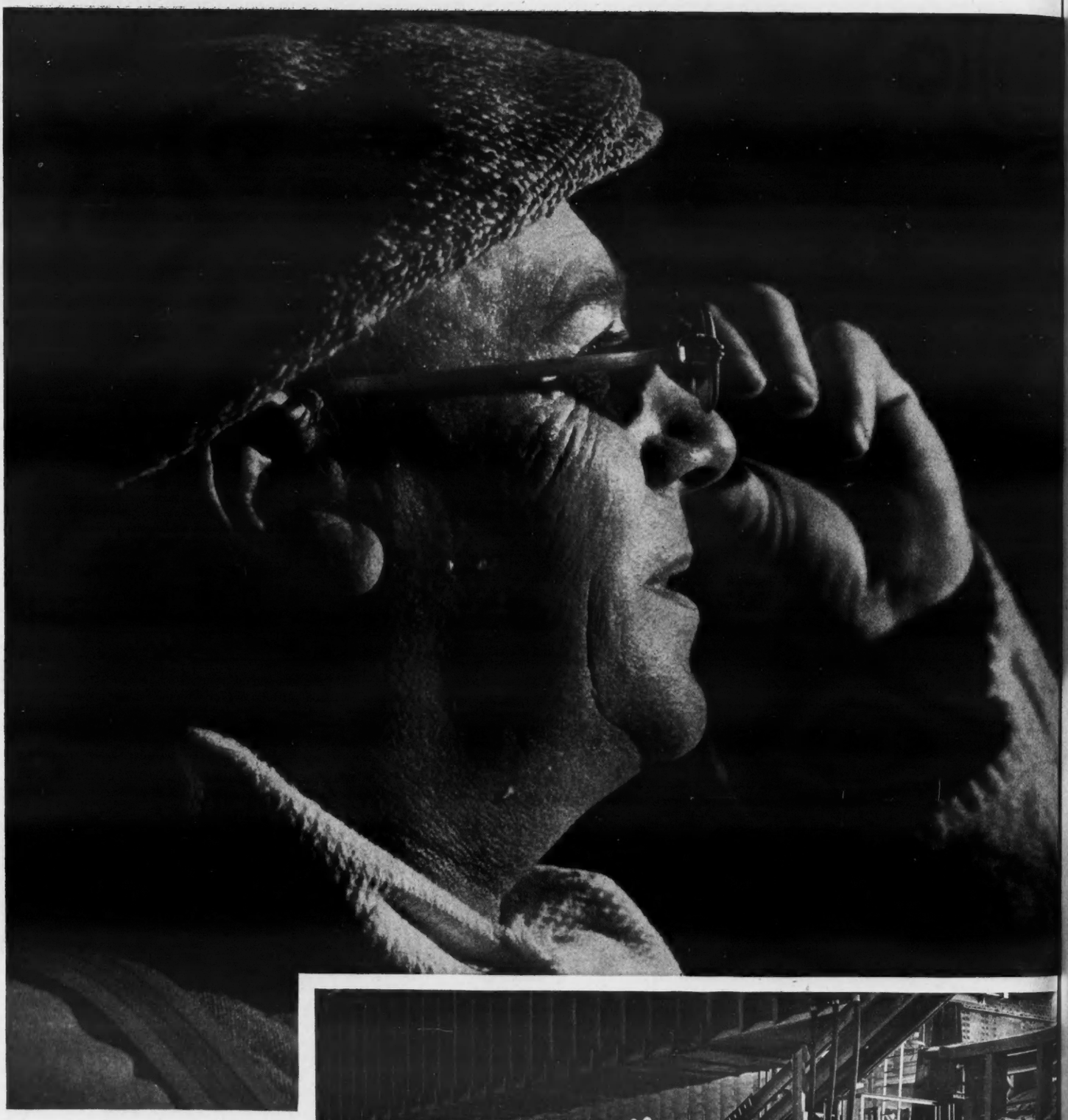
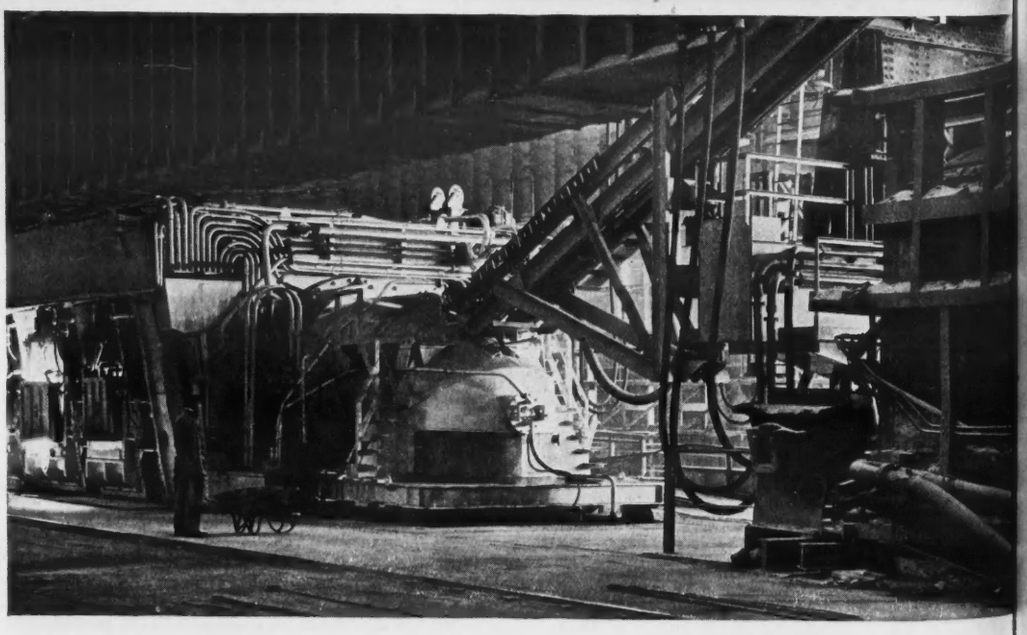


MR. LOMAN WELCH, first hand melter at the Appleby-Frodingham works of United Steel, Scunthorpe, will go to New York to show how he operates the 'Ajax' furnace. This new oxygen-breathing furnace has a record-breaking output 50% above normal, of finest quality steel.



'AJAX' STEEL FURNACE ▶

U.S. to get an eye-opening look at Britain's modern steel industry

NEW YORK in June. That's when Americans will be rolling up in their thousands at the British Exhibition. And there they'll see an eye-opening display of what Britain's steel industry can do.

Britain led the world in creating plentiful low-cost steel. It was an Englishman, Bessemer, who by inventing his "converter" turned steel from a rarity into an everyday necessity. Another Englishman, Brearley, discovered stainless steel.

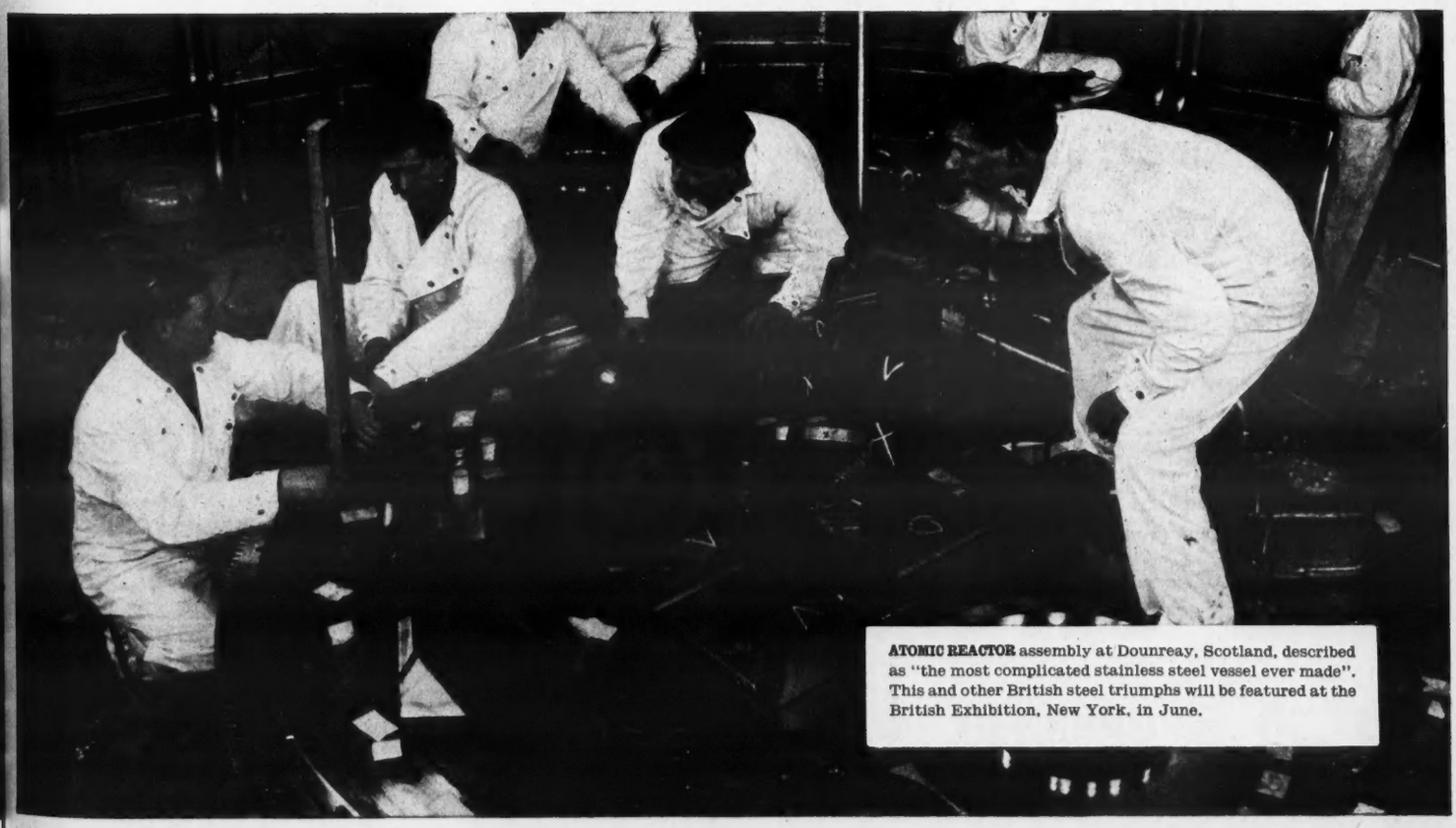
But the accent will be on the modern developments that are putting Britain right in the forefront of steelmaking progress. One of the highlights of the Exhibition will be 'Ajax'—a new type of British steel furnace that is giving record outputs, 50% above normal. 'Ajax' furnaces breathe in oxygen and yield top quality steel in prodigious quantities. Up to 5,000 tons per week and more—from a single furnace!

New alloy steels have been developed for use in atomic reactors—including boron steel, which absorbs neutrons. As originally made, boron steel was too brittle to shape: but British steel scientists overcame this difficulty.

Visitors to the Exhibition will learn about some of the superb things made nowadays with British steel, from sports cars to radio telescopes and from precision tools to jet engines. The steel industry will show the vital contribution it is making to Britain's present-day prosperity.

A feature on the steel industry's display in New York forms part of the British Iron and Steel Federation's "Spring Report to the Nation".

The British Iron and Steel Federation, Steel House, Tothill Street, London, S.W.1.



ATOMIC REACTOR assembly at Dounreay, Scotland, described as "the most complicated stainless steel vessel ever made". This and other British steel triumphs will be featured at the British Exhibition, New York, in June.

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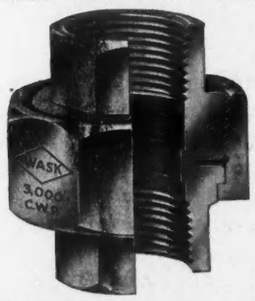

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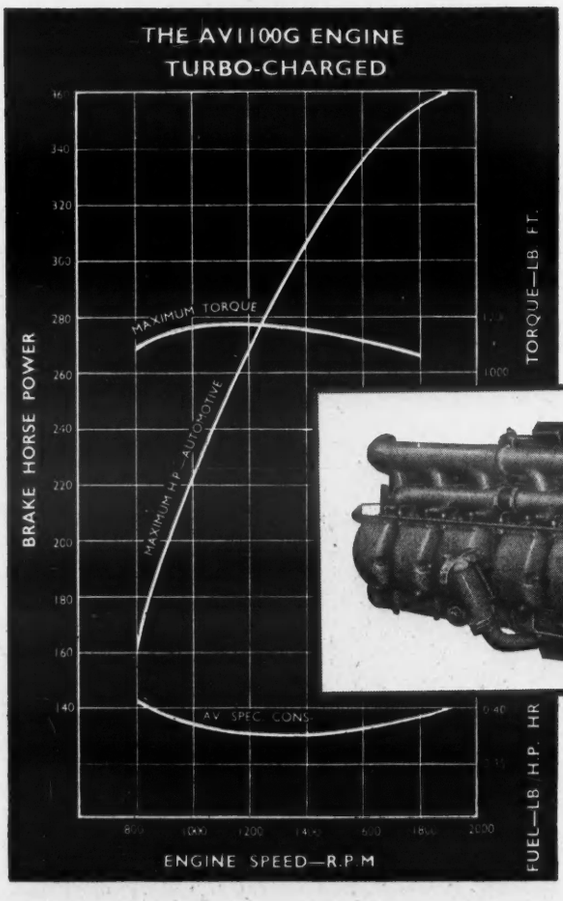
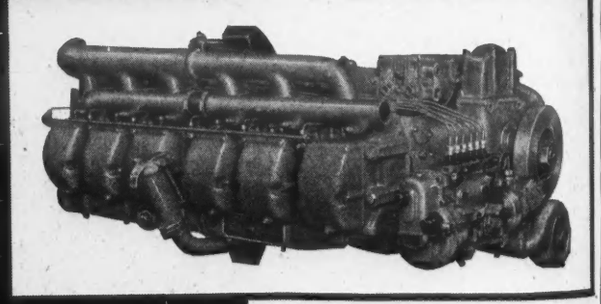


The AH100G horizontal Industrial Diesel



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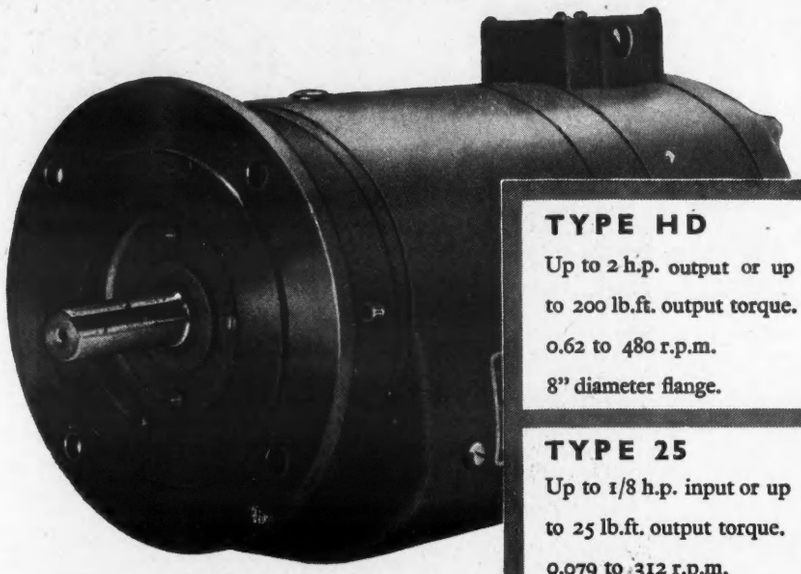
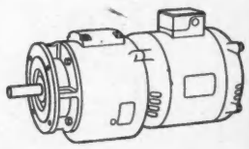


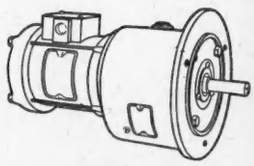
TYPE HD

Up to 2 h.p. output or up to 200 lb.ft. output torque. 0.62 to 480 r.p.m. 8" diameter flange.



TYPE 25

Up to 1/8 h.p. input or up to 25 lb.ft. output torque. 0.079 to 312 r.p.m. 8" diameter flange.



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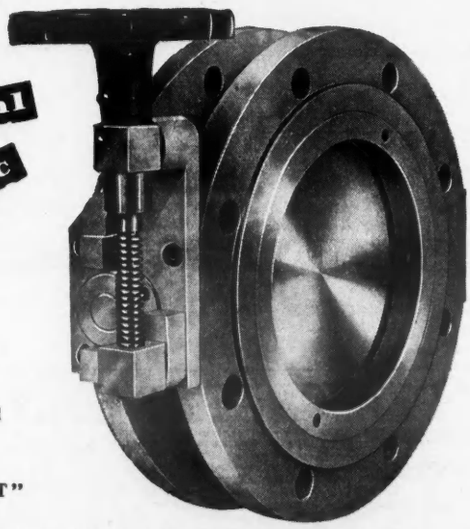

Suitable for Water, Oil, Paraffin, Air, etc., up to 150 P.S.I. Weight approx. ¼ that of usual type of valve.

Standard "FLEXISEAT" Valves are supplied for test pressures up to 300 P.S.I. 3in., 4in. and 6in. sizes available from stock.

"Specials" up to 60in. bore can be made to customers' requirements in terms of pressure, temperature and material specification, etc.

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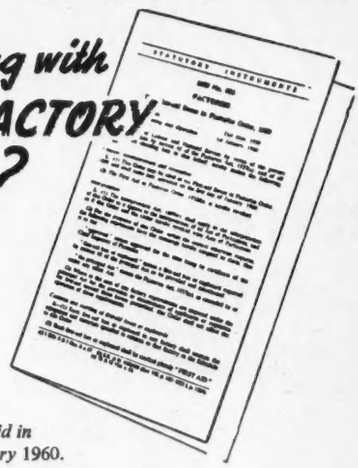

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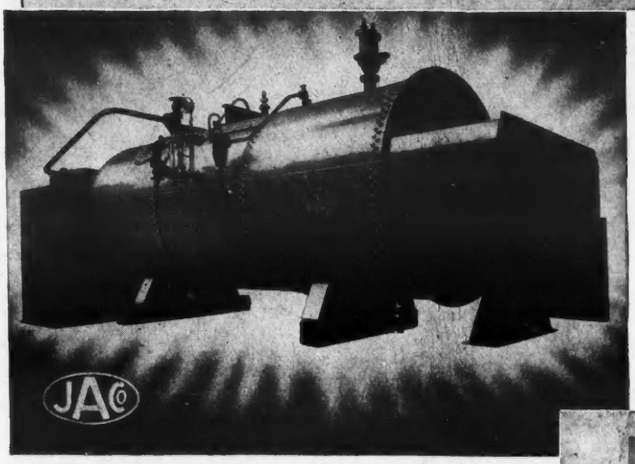
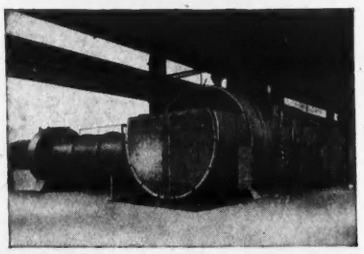
JOSEPH ADAMSON
Waste Heat Boilers





The Joseph Adamson Waste Heat Boiler is designed to make efficient use of the waste gases leaving open-hearth furnaces, reheating furnaces, soaking pits, gas retorts, etc.

The straight-through fire tubes have a high ratio of length to bore, giving about 90% tube efficiency and providing a large area of heating surface in a comparatively small space. Brickwork setting is not required and air infiltration is thus avoided.

A feature of Joseph Adamson Waste Heat Boilers is that a special cleaning device can be provided in the outlet chamber to allow the tubes to be cleaned while the boiler is at work.

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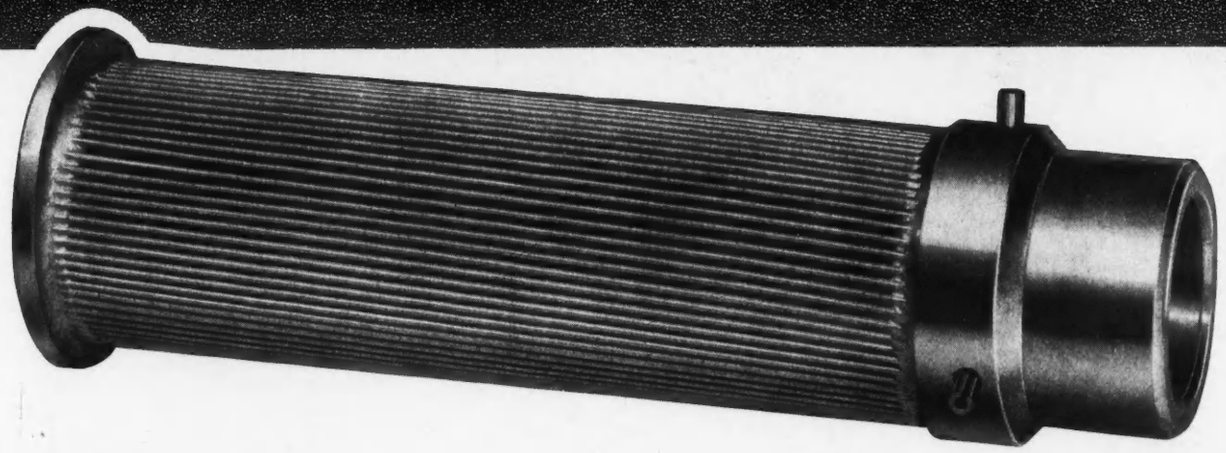

POROLOY CM.

Vokes now introduce a new all-metal filter medium of outstanding efficiency for the *controlled* filtration of hydraulic and lubricating oils, fuels, air, gases, acids, caustics and related caustic materials, chemicals and solvents at extreme temperatures and pressures. Poroloy CM filter elements can be made in any size or shape from a variety of metals—Stainless Steel, Inconel, Nickel, Copper, Steel and Nichrome being the most popular—features which, combined with special production techniques to give controlled pore configuration, enable filters to be individually designed for special applications. Metals can be selected with the particular requirements of the application in mind and the size of the pores can be controlled to deal with particles of between 2 and 250 microns. Poroloy CM filters are therefore 100% effective against a stated particle size, *the danger of media migration being eliminated by an accurately controlled sintering process.* The ultimate tensile strength of the elements varies from 2,000 to 60,000 p.s.i. and the operating temperature range is from −400°F to 1200°F.

The unique combination of properties found in Poroloy CM has led to its recent use in critical temperature conditions in the United States missile and aircraft industries, including installation in the Boeing 707.

POROLOY T.

Similar in performance to Poroloy CM but manufactured by a different process, Poroloy T has an operating temperature range from −400°F to 1500°F. Pore size ratings are from 2 to 250 microns and tensile strength varies from 2,000 to 100,000 p.s.i.

The illustration (above right) shows the many sizes and forms—seamless tubes, flat discs, corrugated elements etc.—in which Poroloy can be manufactured.

Both filter elements are manufactured in conditions of micro-cleanliness and before despatch are individually checked for performance in the bubble point testing equipment (right).

Poroloy was developed by the California Institute of Technology and is manufactured in the U.K. under license from the Bendix Aviation Corporation, U.S.A.

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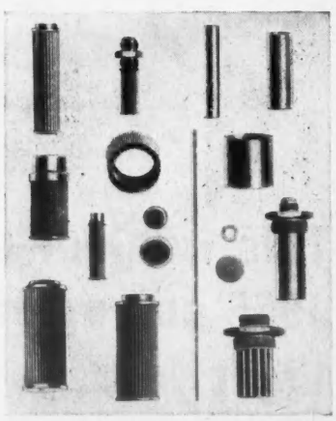

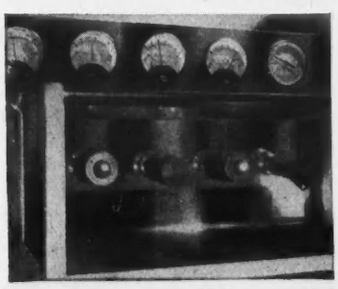

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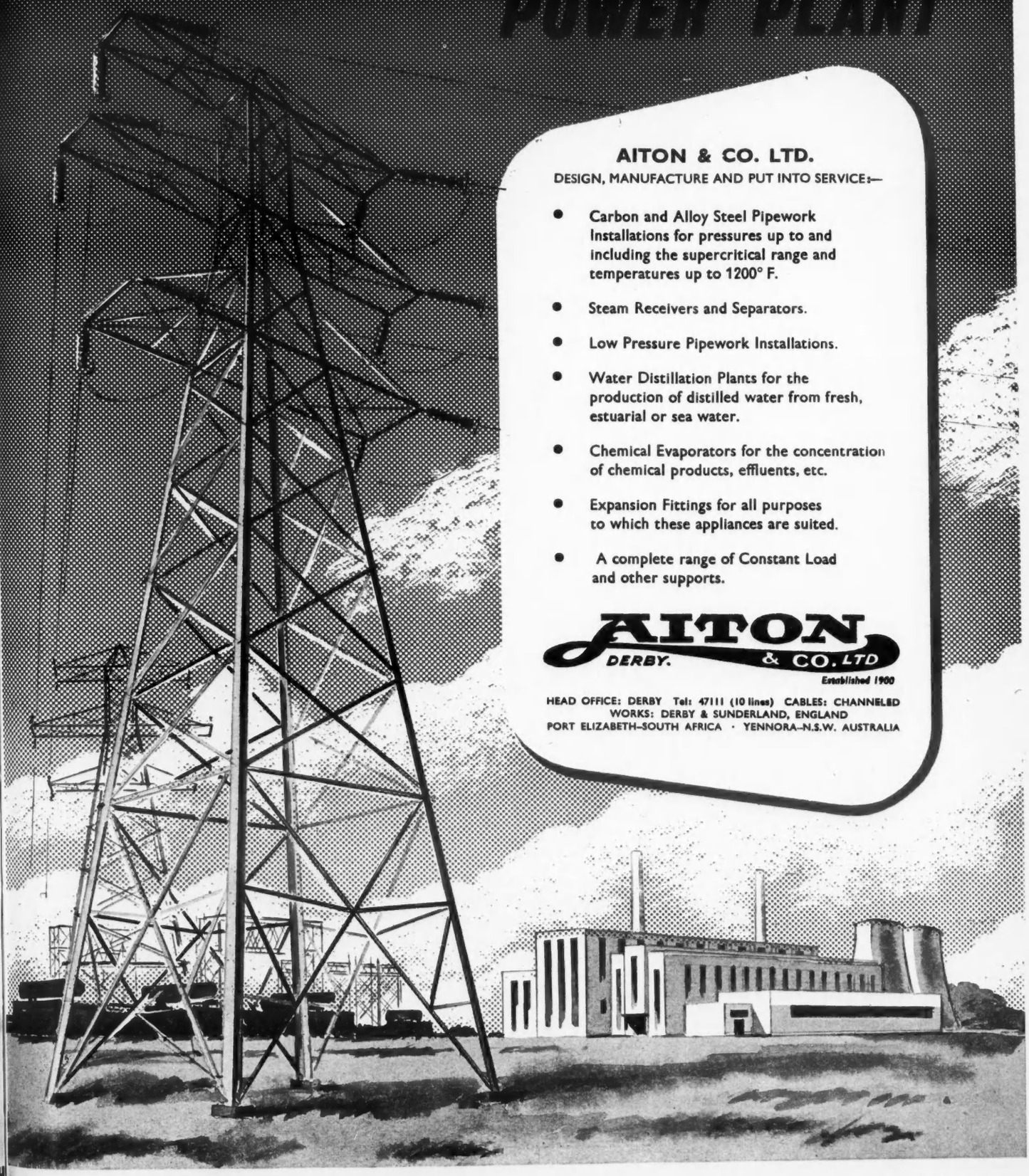

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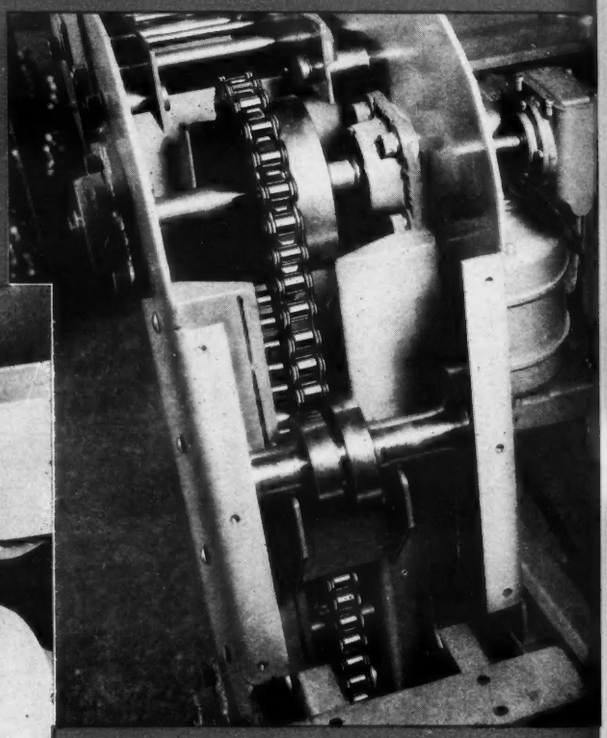

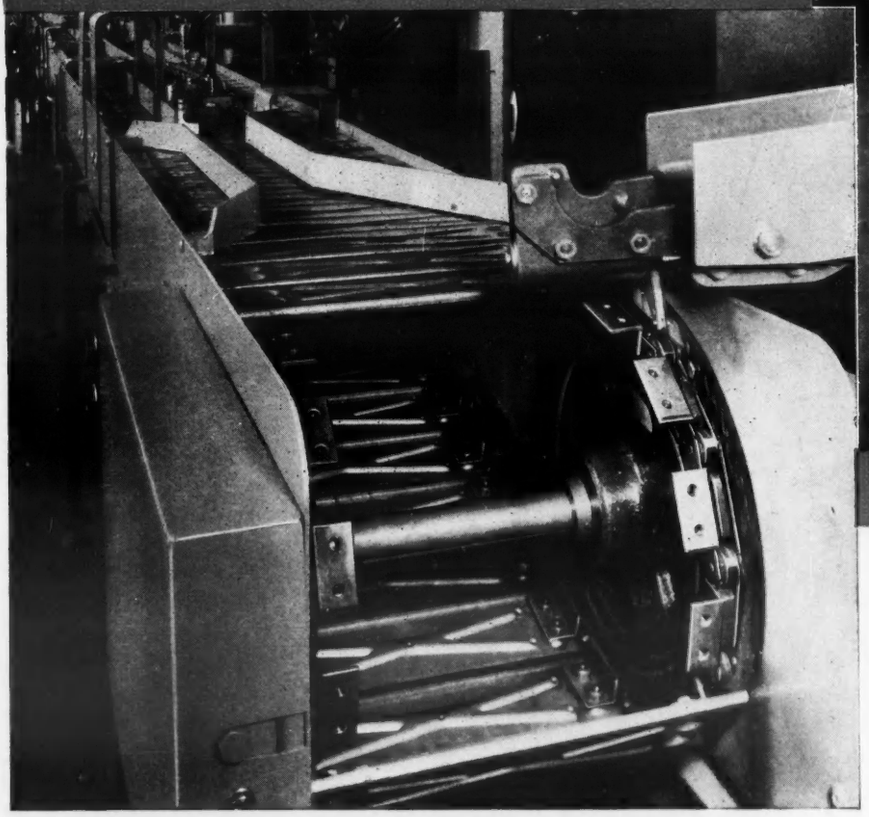

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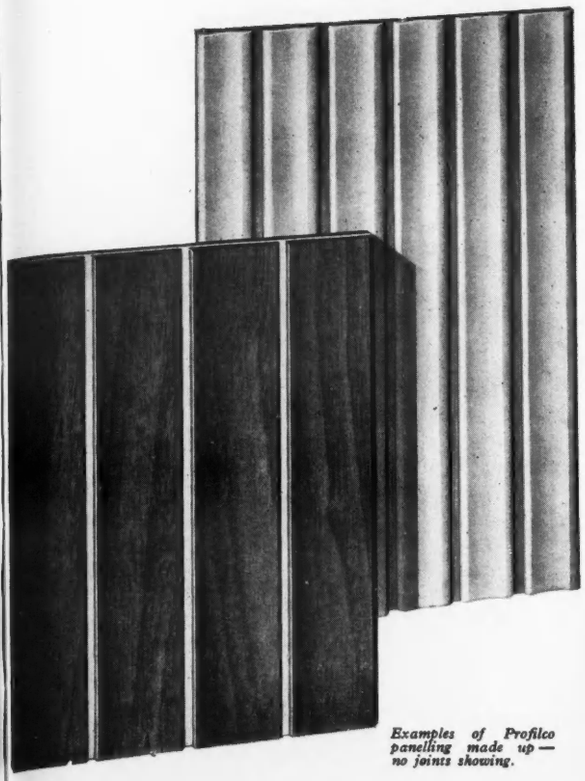

Examples of Profilco panelling made up — no joints showing.

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Mahogany throughout 333.
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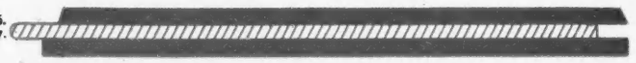
Mahogany face, Obeche core 313.
96" long, 3¼" wide.

Obeche face, Mahogany core 315.
Mahogany face, Obeche core 317.
Mahogany throughout 334.
96" long, 3¼" wide.

Obeche face, Mahogany core 324.
Mahogany face, Obeche core 325.
Mahogany throughout 335.
96" long, 3¼" wide.

Obeche face, Mahogany core 326.
Mahogany face, Obeche core 327.
96" long, 3¼" wide.



Mahogany throughout 310.
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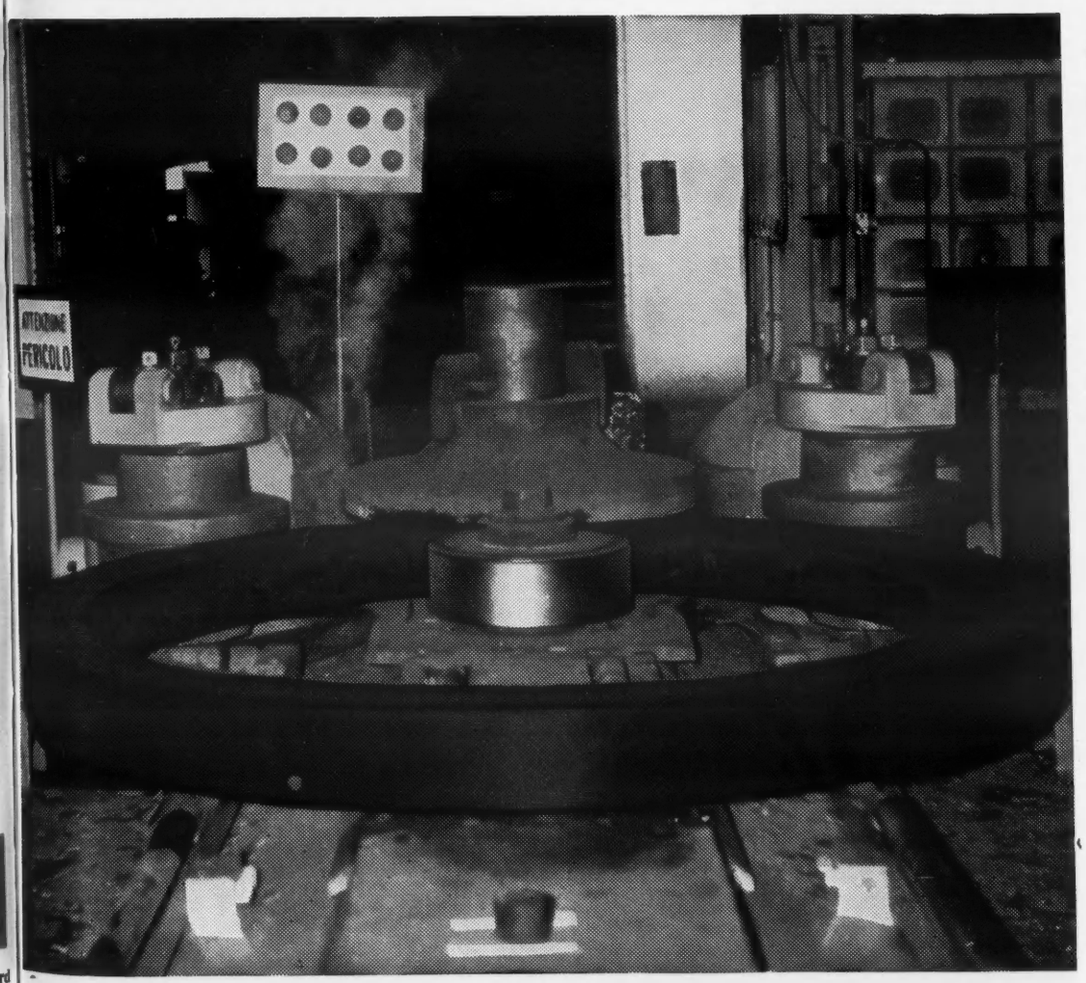

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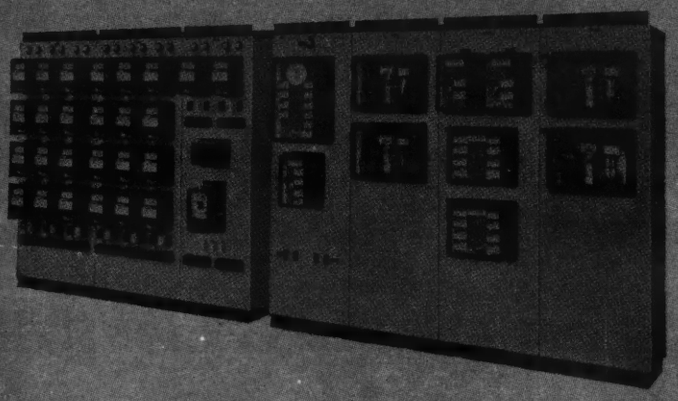
FERRANTI at KARIBA

Ferranti Summation Metering Panels for the Kariba Power Station.



The transformers and summation metering panels are for these sites.

TRANSFORMERS

All the sub-station transformers for the Kariba Hydro-Electric Scheme are being supplied by Ferranti Ltd. They comprise two 120,000 kVA, 330/234 kV 3-phase auto transformers with series boosters, eight 60,000 kVA, 330/88kV and four 60,000 kVA, 330/33 kV 3-phase double wound transformers. The transformer installations at Norton, Lusaka and Kitwe are complete. Work at Salisbury, Bulawayo and Sherwood is well advanced.

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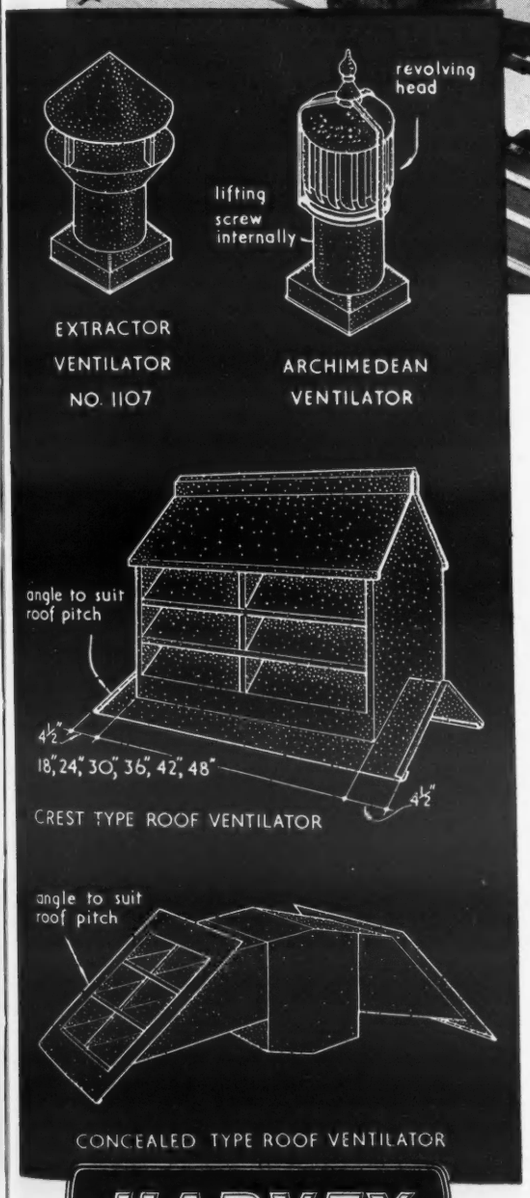

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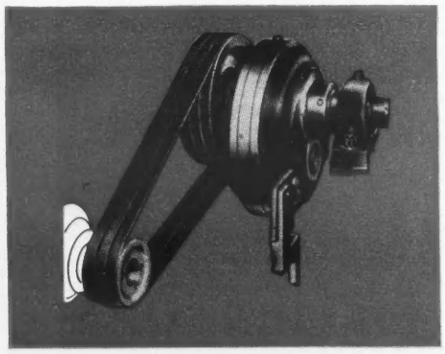

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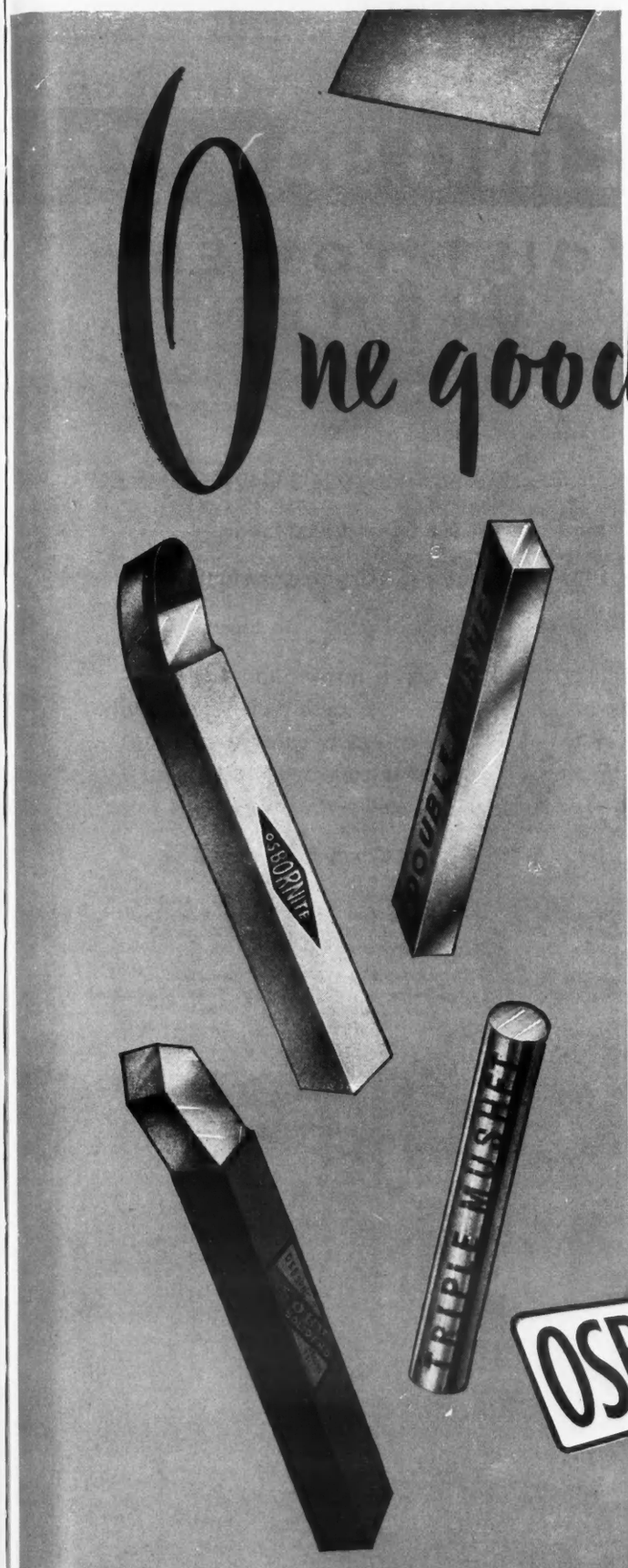

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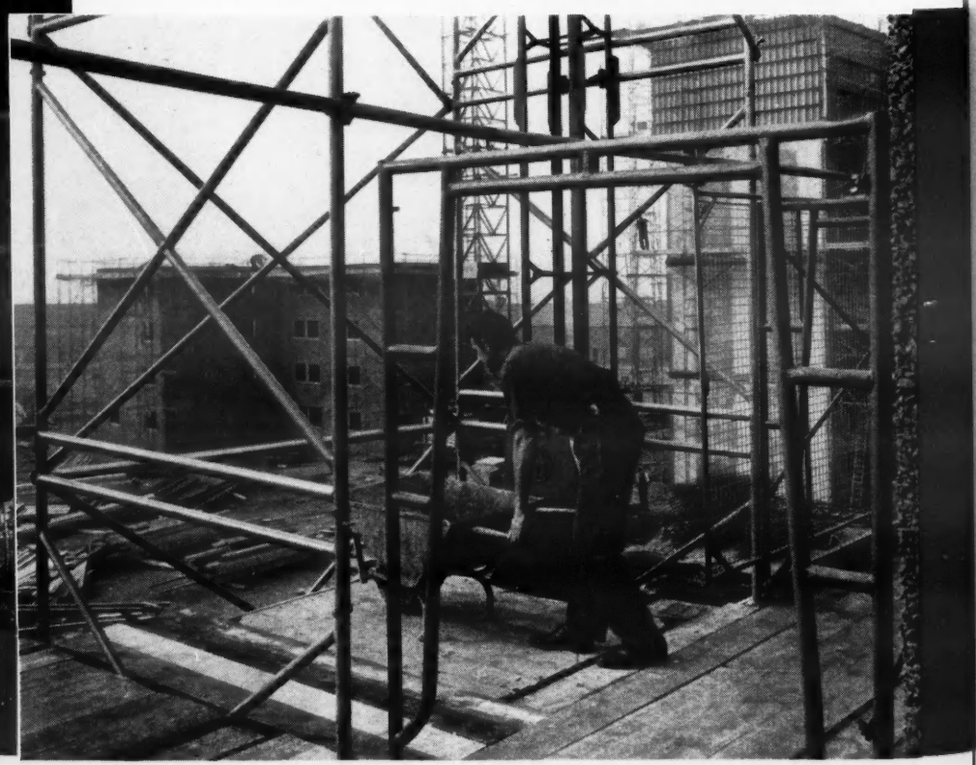

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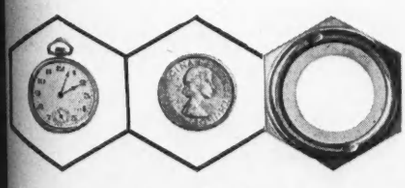

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* *All times shown are based on "The Handbook of Standard Time Data for Machine Shops" by Haddon & Genger, published by Thames & Hudson Limited, London.*

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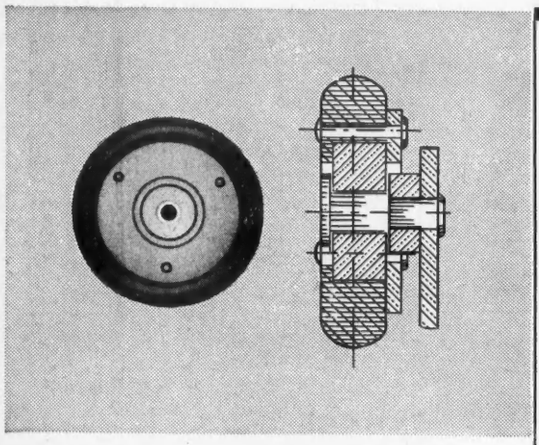

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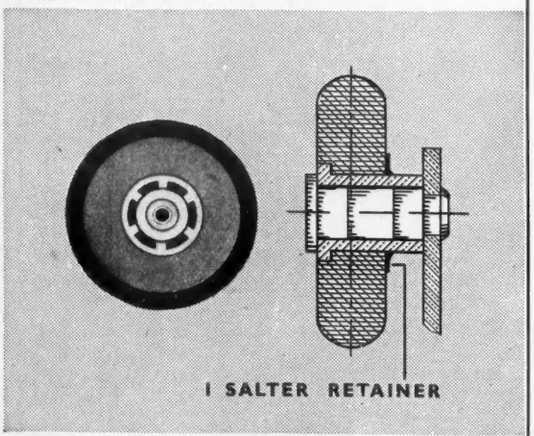

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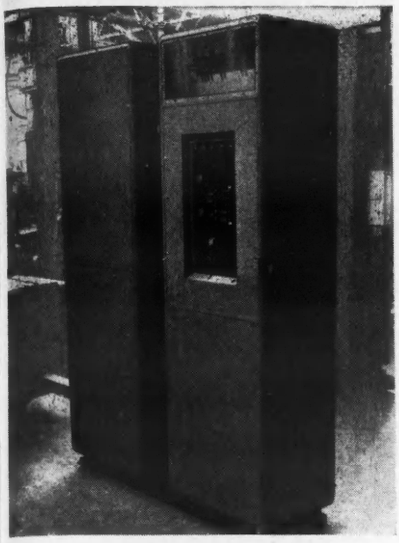

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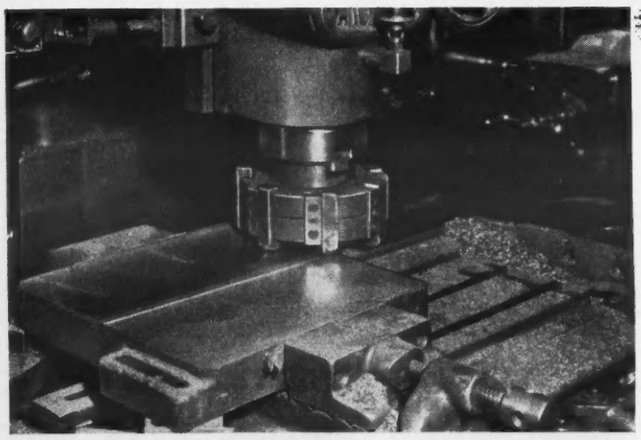

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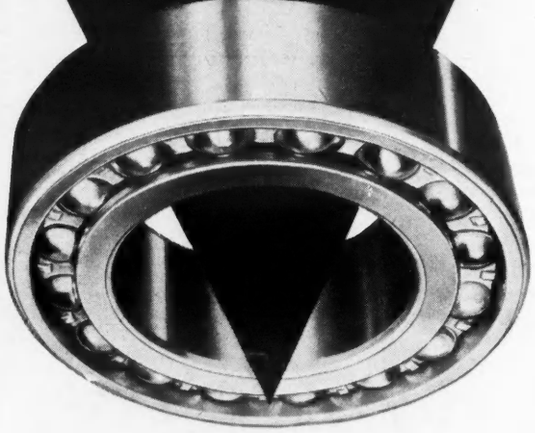

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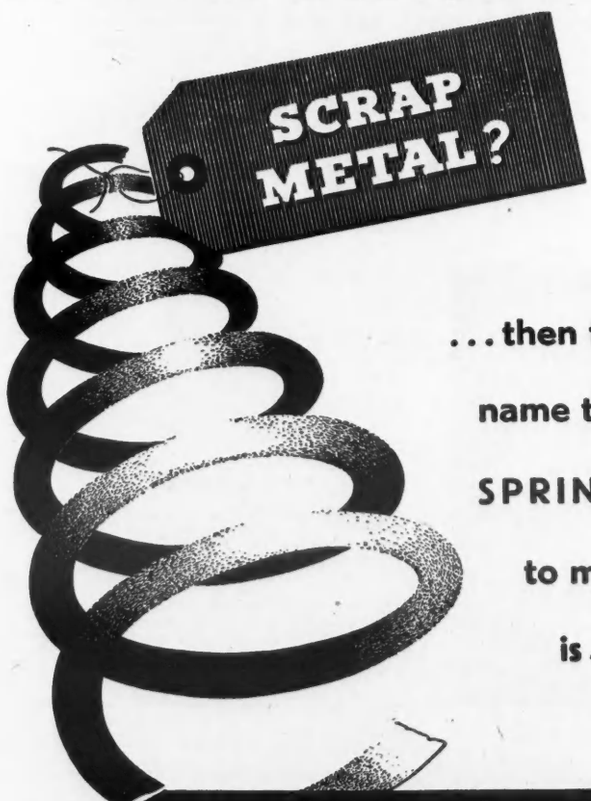

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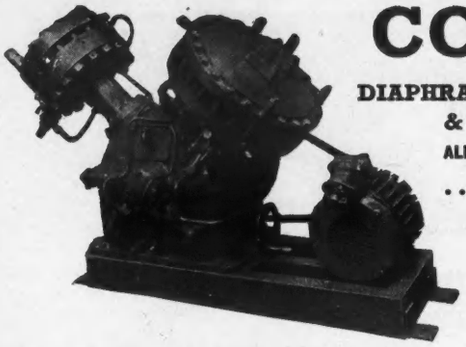

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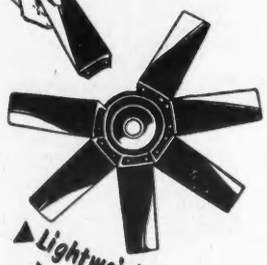
The new patented "Multi-Wing" Axial Fan Impeller has blades moulded from Polyethylene or Nylon with nylon or die-cast aluminium centre. By providing blade sets of varying numbers and pitches in conjunction with various hub diameters, a wide range of fan duties is obtainable. Due to their lightweight construction "Multi-Wing" Impellers are not subject to any appreciable unbalance, thus reducing vibration to a minimum. "Multi-Wing" Blades are not affected by corrosive fumes and are adaptable for many purposes.



▶ Lightweight
▶ Strong
▶ Silent
▶ Spark-proof
▶ Acid-proof

Blades are strong but can be replaced quickly and cheaply in the event of accidental damage.

"Airflo" MULTI-WING FAN

Range:- 10-24 inch diameter Send for List.

Industrial Fan & Heater Co. Ltd

"Airflo" WORKS, BIRMINGHAM, 11. Phone: VIC 2277

and at LONDON, MANCHESTER, SWANSEA

A MEMBER OF THE SIMMS GROUP OF COMPANIES

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INTRODUCING THE

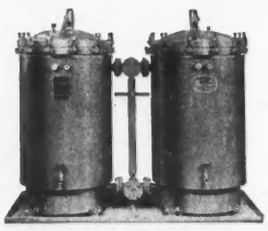
BIRFIELD HILCO range of OIL FILTRATION EQUIPMENT

'C' SERIES FILTERS

For high flow rate filtration of internal combustion engine lubricating oils using by-pass shunt or full-flow systems. Also for filtration of various types of fuel oils, industrial oils, coolants, solvents etc. used in manufacture and the chemical processing industries. These filters can be supplied with or without heaters.

'R' SERIES FILTERS

For the continuous filtration of lubricating and fuel oils used in internal combustion engines, various types of industrial oils, coolants, fuel oils, solvents etc. used in manufacturing industries.
Where floor area is limited the cartridges can be mounted in a number of cases piped in parallel. These are supplied with or without motor pump sets according to requirements.



DUPLEX FILTERS

All filters can be supplied in duplex units where it is essential that continuous filtration is required.

000 SERIES FILTERS

For fuel oil filtration, can be supplied either in duplex or simplex units.

Here is a new range of oil maintenance equipment specially designed for high efficiency operation at lower cost. Birfield Hilco filters will maintain new oil characteristics of any quality industrial and lubricating oils. As there is such a wide range of oils, and the conditions under which they are used require different methods for removing contamination, we have developed six filter medias to cope with these varying conditions.

for **high** efficiency at **low** cost...

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Member of the **Birfield Group**

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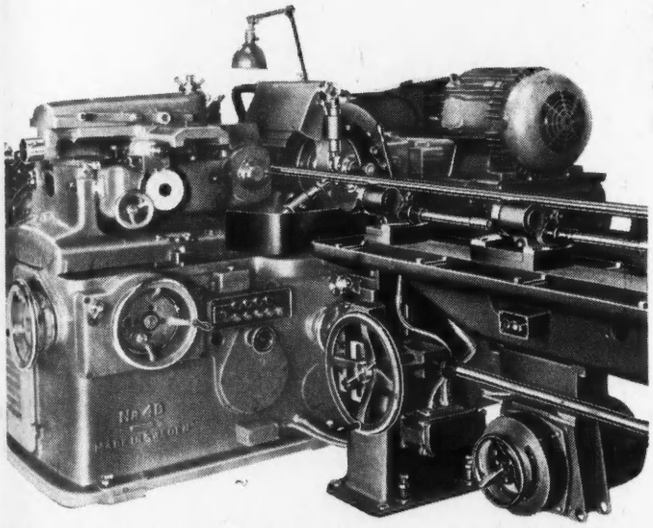
LIDKOPING

Lidkoping No. 5B Centreless Grinding Machine with bar feeding tables for bar up to 8 in. dia. × 20 ft. long.

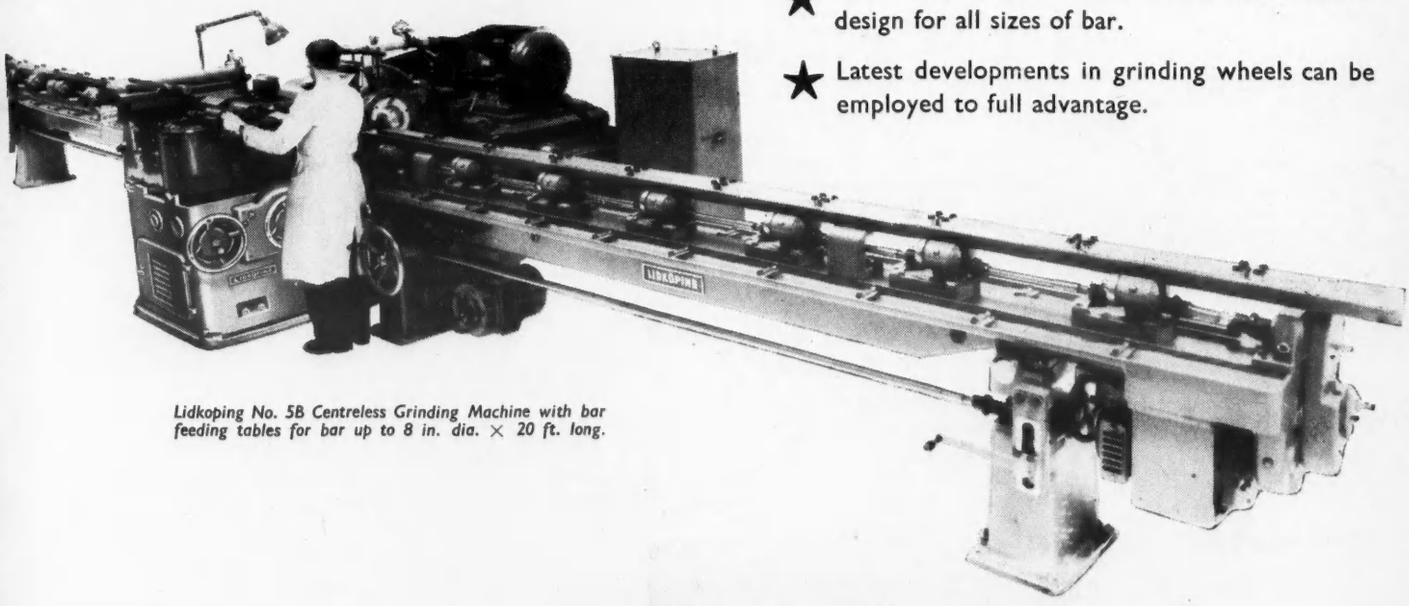
for maximum production on Bar Grinding



Lidkoping No. 4B Centreless Grinding Machine with bar feeding tables for bar up to 4 in. dia. × 14 ft. long.

Lidkoping Centreless Grinding Machines are of exceptionally robust design and incorporate many features which have established their reputation for reliable, accurate, long-run production. Some of their advantages are listed below.

- ★ Greater operating through-feed speed, even for bars above 2 in. dia.
- ★ Largest quantity of stock removal at each pass.
- ★ Highest accuracy of diameter and roundness, even on large diameter work.
- ★ Quick change-over from one diameter bar to another.
- ★ Black-rolled material ground as easily as drawn or turned stock.
- ★ Power-driven roller tables of the most modern design for all sizes of bar.
- ★ Latest developments in grinding wheels can be employed to full advantage.



Lidkoping No. 5B Centreless Grinding Machine with bar feeding tables for bar up to 8 in. dia. × 20 ft. long.

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DRUMMOND-ASQUITH LIMITED

Member of the Asquith Machine Tool Corporation

KING EDWARD HOUSE, NEW ST., BIRMINGHAM *Phone: Midland* 3431. *Also at LONDON Phone: Trafalgar* 7224 & *GLASGOW Phone: Central* 0922

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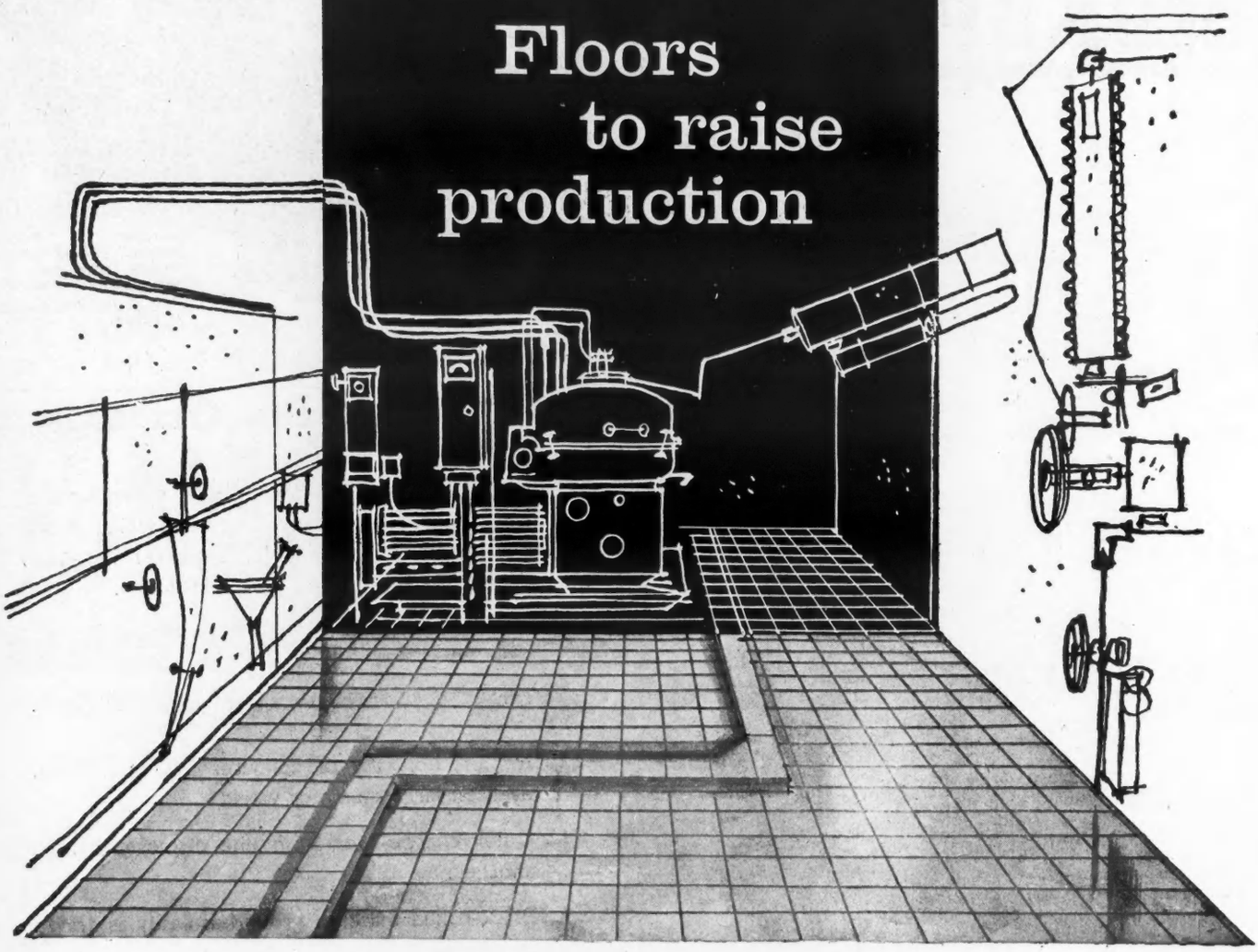
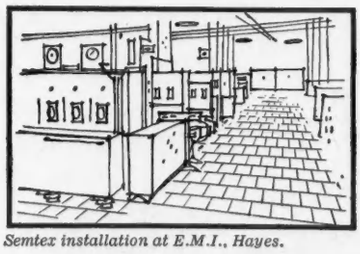
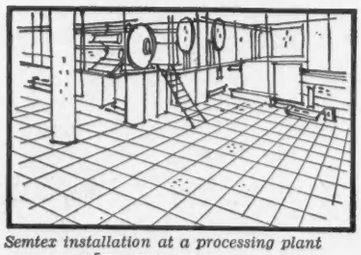
Floors to raise production





Semtex installation at E.M.I., Hayes.



Semtex installation at a processing plant of the Nestlé Co., Ltd.

A Semtex installation at the Ellesmere Port Refinery of the Shell Chemical Company Limited.

The installation of practical, hard-wearing and corrosion resistant floors will save you time and money in putting an end to constant repairs and in improving your annual turnover by uninterrupted production. Semtex, specialists in all types of flooring, will take over your entire flooring operation, designing, transporting and laying materials which proof factory floors, storage bays and machine beds against corrosive agents and mechanical wear. Continued research into the special problems confronting industry has led Semtex to the fore in the manufacture of new materials and in the development of the most comprehensive flooring service in the business.
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A DUNLOP COMPANY

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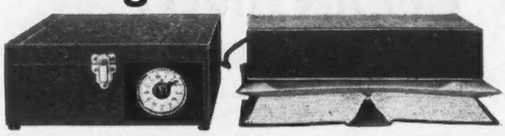

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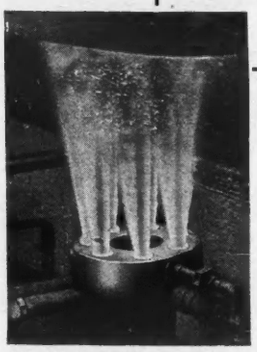

HIGH EFFICIENCY *'TARGET'*
—Gas Burners for all purposes

Many new gas burner applications are possible by the introduction of "Target" gas burners. In this system, air and gas are intimately mixed producing pencil flames of high intensity which require no additional air for combustion. It is therefore suitable for use in the open or in closed combustion spaces. The velocity of the mixture issuing from the jets promotes turbulence and high rates of heat transfer. The burner consists of mutiple jets which can be arranged to suit any flame pattern.

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Telephone: HEATON MOOR 6251 (5 lines) Telegrams: Gasify, Manchester 19

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SPECIALISTS IN COMPONENT PRODUCTION FOR THE MOTOR INDUSTRY

EQUIPMENT FOR ENGINE TEST BENCH
Flowmeters for all types of petrol engines to give instantaneous readings of fuel consumption. Jet calibrating machines for the checking of carburetter jets to British Standard 720-1948 and of jets for liquids and gases in the process of manufacture.

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Carburetters; flame traps; fuel pumps and filters; ball and roller joints for controls.

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Fuel pumps; fuel filters; bonnet fasteners; ball and roller joints; push-pull controls.

MOTOR CYCLES & SCOOTERS
Carburetters; handlebar controls (twist grips and levers); control cable and non-fray wire; air filters.

A 293

Enquiries should be addressed to
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Telegrams: Amalcarb, Phone, Birmingham Telephone; Birchfields 4671 (5 lines)

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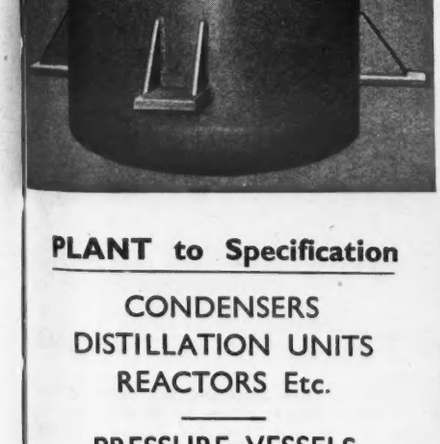

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ALUMINIUM
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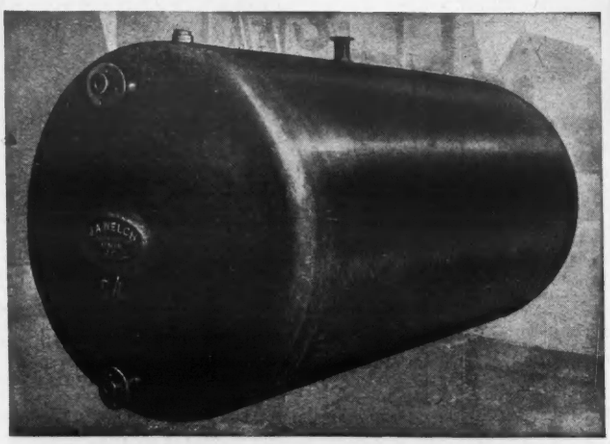

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PRESSURE VESSELS
OF ALL KINDS

DELIVERIES PROMPT
PRICES COMPETITIVE

CRAFTSMANSHIP IN
ALL METALS

J. A. WELCH (PLANT & VESSEL) LTD.
STALCO WORKS, LIVINGSTONE RD., LONDON, E.15
TELEPHONE: MARYLAND 5818 (3 lines).

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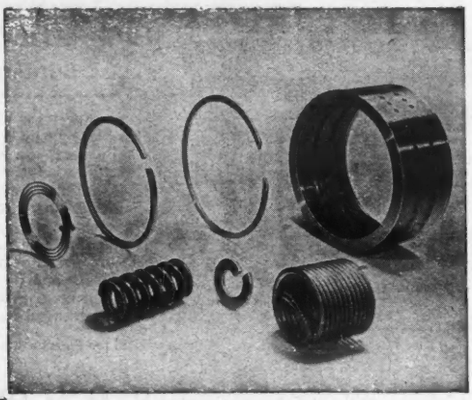
Where Top Standards are required—

CROSS British made components are consistently being specified for use in the products of the future. Where top standards are required CROSS components are essential, they are manufactured using a specialised hardening and tempering process, and are extremely accurate.

WIRE THREAD INSERTS
SPRING WASHERS
CIRCLIPS and RETAINING RINGS
JET ENGINE LABYRINTHS



CROSS MANUFACTURING CO. (1938) LTD.
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AIR CLEANSING . . .
THE TORNADO WAY

Mr. Manufacturer please do not allow your employees to work in conditions where air pollution exists.

Dirt costs time and money !

For a very reasonable outlay you can protect your staff from dangerous fumes, grit and dust, by using the :

TORNADO CLEAN AIR EQUIPMENT

Are you interested SIR ?

If so please phone at once and allow us to quote.

Fully trained personnel are at your disposal.

BARNET METAL CO. LTD.
Elektron House, Brookhill Road, New Barnet, Herts.
Telephone : BARnet 3901/5187
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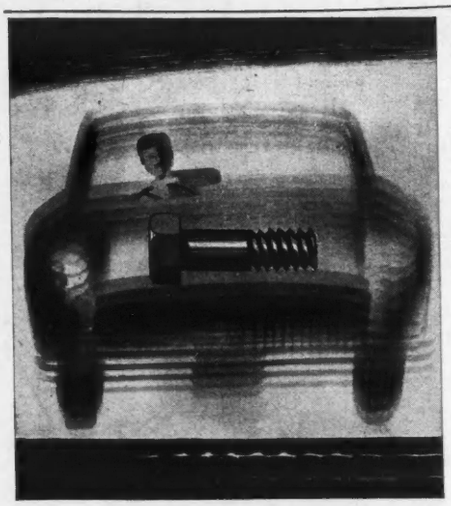

get a lead on H.T.*

* H.T., in this instance, stands for High Tensile—High Tensile bolts from Lanarkshire which stand no nonsense from the stresses and strains imposed by engine vibration, chassis flexing, body movement. If you want to anticipate the unexpected, specify Lanarkshire H.T. bolts. Bolts offered on 'immediate return' delivery terms in R, T and V grades embracing 45-75 tons range. Bolts 'off-the-shelf' in B.S. 1083 (Whitworth and B.S.F.) and B.S. 1768 (Fine and Coarse) threads. And if you have a special design in mind—Lanarkshire are the people to do it well, do it cheaply *and do it quickly*.

***DON'T CHASE BOLTS**—trace them—quickly—with the Lanarkshire Stock List on hand. Issued FREE every month, buyers tell us it's a great boon in requisitioning.*

Ask to have your name put on the mailing list.

LANARKSHIRE BOLT LIMITED
Hamilton, Lanarkshire, Scotland. Tel: Hamilton 1241/4
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Consult FILTON For Rotary Unions—

Unions fitted with carbon bearings are available for temperatures over 400°

For use on all types of Rotary and Semi-Rotary machines for Leakproof Fluid Transfer
Standard Sizes ¼"—3" B.S.P.
Special Sizes & Designs up to 6" B.S.P.

As used by leading Engineering Companies and Government Departments

FILTON LIMITED,
CLAPHAM STREET, LEAMINGTON SPA, WARWICKSHIRE
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ABIX **ADJUSTABLE STEEL SHELVING**

The illustration shows a typical installation of ABIX Steel Shelving, supplied to a well-known Paint Manufacturer. Note the easy access to the shelving and the orderly appearance.
ABIX Steel Storage Equipment is supplied in a number of Standard components which can be used to make up an infinite variety of assemblies to suit your particular need. These components can be erected and dismantled by unskilled labour in a minimum of time.
They are Steel throughout. Stove Enamelled Olive Green. All fixing bolts are galvanized.

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STEEL EQUIPMENT FOR OFFICE AND FACTORY
POOL ROAD, WEST MOLESEY, SURREY
Phone: MOLesey 4361/3 Grams: Abix, East Molesey
OTHER ABIX PRODUCTS: Steel Cycle Stands, Clothes Lockers, Slotted Angle Stillages and Pallets
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overhead travelling cranes

For overhead travelling cranes up to 90 ft. span and 10-ton capacity, cabin-controlled or floor-controlled, Acrow-Demag design and quality of workmanship cannot be surpassed.

Remember, also, that all Acrow-Demag motors are of the tapered-rotor, self-braking type, reducing brake maintenance to a minimum, and you will agree that in Acrow-Demag Overhead Travelling Cranes you have

the best you can buy – and at the right price!

To test our claim about price, let us submit a comprehensive scheme and quotation

ACROW (ENGINEERS) LTD., DEMAG DIVISION, South Wharf, London, W.2
Telephone: AMBassador 3456 (20 lines)
Branches: BIRMINGHAM, BRISTOL, CARDIFF, GLASGOW, LEEDS, LIVERPOOL, MANCHESTER, NEWCASTLE, SAFFRON WALDEN, SOUTHAMPTON & BELFAST

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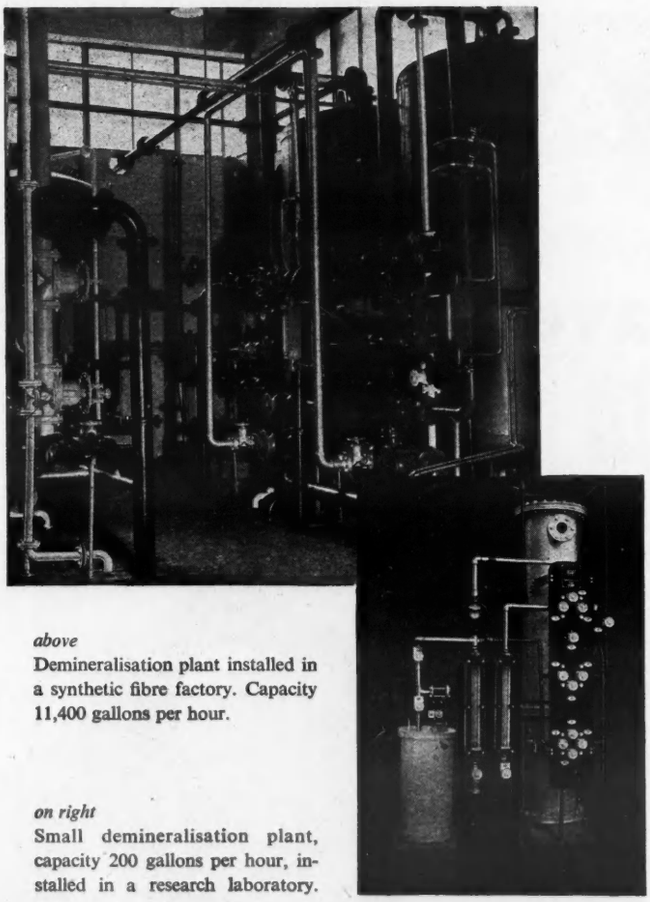
DEMINERALISATION

Supplied to many of the leading Industrial Organisations and Corporations in Gt. Britain and Overseas, including



above
Demineralisation plant installed in a synthetic fibre factory. Capacity 11,400 gallons per hour.

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Small demineralisation plant, capacity 200 gallons per hour, installed in a research laboratory.

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Established in 1875

WILLIAM BOBY & CO. LTD.
RICKMANSWORTH, HERTFORDSHIRE, ENGLAND. Tel: Rickmansworth 4251*

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Two 120-ton and One 30-ton Vaughan Overhead Cranes

the CRANE for the JOB

Some of the types of VAUGHAN Cranes:—

LIGHT DUTY
MEDIUM INDUSTRIAL
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STEELWORKS

(Capacity. Minimum 1 ton Maximum 200 tons)

GOLIATH
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SPECIAL PURPOSE
WALL JIB

Specialised Cranes:

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RADIO CONTROLLED
FREQUENCY CONTROLLED
(Automatic or Remote)
TELEVISION CONTROLLED
(Closed Circuit)

Our Engineers at your service anywhere

VAUGHAN CRANES SPAN THE WORLD

Some of the Industries using them:—

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PLASTICS
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In Britain and the rest of the World.

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OVERHEAD CRANES · HOIST BLOCKS · TELPHERS · RUNWAYS

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Manchester 12 · England. Telephone EASt 2771.

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Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/–. **Inch Rate.** 54/– per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

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Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/– which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to :—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

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MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

MECHANICAL RESEARCH ENGINEER

Applications are invited for the post of MECHANICAL RESEARCH ENGINEER in connection with a large research project on the automatic control of machine tools. Candidates should be Graduates or should hold a Higher National Certificate : some knowledge and experience in hydraulics, control engineering or machine tools would be an advantage. Salary in the range £750–£900 per annum.

Applications should be addressed, as soon as possible, to the Registrar, The Manchester College of Science and Technology, Sackville Street, Manchester, 1, from whom further information may be obtained. E9826

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, ST. JOHN STREET, LONDON, E.C.1

LECTURERS AND SENIOR LECTURERS IN MECHANICAL ENGINEERING

These vacancies arise from the continued expansion of the College in Degree, Diploma in Technology and post-graduate studies.

Salary scales : Lecturer, £1408, rising to £1601.
Senior Lecturer, £1588, rising to £1801.

Particulars and forms of application are available from the Secretary, to whom applications should be sent by 5th June. E9808

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF MECHANICAL ENGINEERING

CHAIR OF MECHANICAL ENGINEERING

Applications are invited for the CHAIR OF MECHANICAL ENGINEERING and Headship of the Department. Salary £3100 per annum, with membership of the Universities' Superannuation Scheme and children's allowances. Conditions of Appointment and Form of Application, which should be returned by 30th June, 1960, from the Registrar. E9841

KUMASI COLLEGE OF TECHNOLOGY, GHANA

SCHOOL OF ENGINEERING

SENIOR TECHNICAL ASSISTANT

Applications are invited for the post of SENIOR TECHNICAL ASSISTANT in the Department of Electrical Engineering.

Applicants should hold the Higher National Diploma or Certificate or equivalent, and should have experience in operation and maintenance of electronic equipment. The College prepares students for the B.Sc. External degree of London University.

Contract appointments are normally for five years, and may be renewed. Three months' notice of resignation of an appointment is required on either side.

The contract salary scale is £1017 10s. by £44 to £1475 10s. per annum.

In addition children's allowances are paid up to a maximum of three, and a gratuity at the end of the contract at the rate of £150 for each year of satisfactory service. The entry point is fixed according to qualifications and experience.

The College is fully residential and members of staff are housed in pleasant modern bungalows on the spacious campus ; climate and living conditions are good.

Annual leave with three free return passages in four years is granted to members of staff and their families.

Application forms and an Information Brochure may be obtained from the Assistant Registrar, Kumasi College of Technology, 29 Tavistock Square, London, W.C.1, who will also be glad to answer any questions about these appointments. The closing date for applications is mid-June. E9857

PUBLIC APPOINTMENTS

UNIVERSITY OF ABERDEEN AND ROBERT GORDON'S COLLEGES

UNIVERSITY LECTURERS

Applications are invited for the following posts :

UNIVERSITY LECTURER IN MECHANICAL ENGINEERING. Candidates should have special qualifications in applied thermodynamics. An interest in Heat Transfer apparatus, or in the special problems associated with the generation of Heat and Power from Nuclear Reactors, and some industrial or research experience would be an advantage.

UNIVERSITY LECTURER IN ELECTRICAL ENGINEERING.

Excellent facilities for research or advanced studies. University Regulations permit members of teaching staff to read for degree of Ph.D. by research.

Salary on scale rising to £1850 with placing according to qualifications and experience ; superannuation (F.S.S.U.), children's allowance, and removal allowance. University houses available from time to time.

Further information may be obtained from The Secretary, The University, Aberdeen, with whom applications (20 copies) giving names of three referees, should be lodged not later than 3 June, 1960. Applicants outside the British Isles may submit one copy of application. E9856

CARMARTHENSHIRE EDUCATION COMMITTEE

AMMANFORD TECHNICAL COLLEGE

DEPARTMENT OF ENGINEERING AND MINING

LECTURER

Applications are invited for the post of full-time LECTURER IN ELECTRICAL ENGINEERING at the above-named Technical College.

Candidates should be Graduates in Electrical Engineering, with suitable industrial experience. Teaching experience in a Technical College will be an added recommendation.

Salary in accordance with the Burnham Further Education Report, 1959 (£1370 to £1550), for Lecturers.

Duties to commence on 1st September, 1960, or as soon as possible.

Application forms, which must be returned not later than 11th June, 1960, may be obtained from the undersigned on receipt of a stamped, addressed envelope.

IORWERTH HOWELLS,
Director of Education.

County Education Offices,
County Hall,
Carmarthen. E9864

HAMPSHIRE EDUCATION COMMITTEE

FARNBOROUGH TECHNICAL COLLEGE

Acting Principal : R. E. SMITH, B.Sc. (Eng.), M.I.Mech.E., A.F.R.Ae.S.

SENIOR LECTURERS

Applications are invited for appointments to the following posts in the above College :—

Post I : SENIOR LECTURER IN SERVO-MECHANISMS.

Post II : SENIOR LECTURER IN AIRCRAFT STRUCTURES.

Candidates should hold a University Degree, or equivalent, and preferably have had some industrial and/or teaching experience.

Candidates should be capable of accepting responsibility for teaching the subject for Diploma in Technology and Higher National Certificate. The Dip. Tech. course includes the subject as one in which students may specialise and do their research project.

Facilities for research work are available. Duties to commence on 1st September, 1960.

Salary in accordance with Burnham Scale for Teachers in Technical Colleges, i.e. £1550 by £50 to £1750.

Details and application forms from Principal of College, Boundary Road, Farnborough, Hants, to whom completed application forms should be returned within 10 days of the last appearance of this advertisement. E9873

PUBLIC APPOINTMENTS

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

ENFIELD TECHNICAL COLLEGE

QUEENSWAY, ENFIELD, MIDDLESEX

SENIOR LECTURER IN CIVIL ENGINEERING

Required :

SENIOR LECTURER IN CIVIL ENGINEERING to teach Theory of Structures and Surveying to Final Diploma students. Candidates must be University Graduates in Civil Engineering, corporate members of the Institution of Civil Engineering, and have had industrial, teaching and/or research experience.

Salary within the range : £1588 to £1801 per annum.

Application forms (foolscap s.a.e.) from the Principal, to whom completed forms should be returned within 14 days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee.
E9854

ROYAL MINT

MECHANICAL ENGINEER

Royal Mint has vacancy for a MECHANICAL ENGINEER. Pensionable post. Degree in mechanical engineering or equivalent qualification necessary. Apply in writing for particulars to Establishment Officer, Royal Mint, London, E.C.3. E9852

WARREN SPRING LABORATORY (D.S.I.R.)

STEVENAGE, HERTS

SENIOR SCIENTIFIC OFFICER

Warren Spring Laboratory (D.S.I.R.), Stevenage, Herts, requires SENIOR SCIENTIFIC OFFICER, responsible for origination and development of prototype plant for Chemical Engineering and Mineral Processing research purposes and supervision of subsequent design. Much plant is of novel design and high degree of originality required. Normal drawing-office facilities available. 1st or 2nd Class Hons. Degree and preferably Corporate Membership I.Mech.E. At least 3 years' post-graduate experience required. Experience in engineering design, particularly in field of chemical engineering, an advantage.

Salary range : (Men) £1166–£1380. Housing accommodation available in New Town.

Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting C 401/0A. E9871

ADMIRALTY

ELECTRICAL ENGINEERS

Admiralty require ELECTRICAL ENGINEERS for unestablished (non-pensionable) appointments in Admiralty Corps of Electrical Engineers in Bath and Royal Dockyards. Candidates must be British subjects aged 25 years or over for basic grade (Assistant Electrical Engineer) posts and aged 30 years or over for main grade (Electrical Engineer) posts.

Qualifications : University Honours Degree in Engineering, or equivalent, and have had at least two years' practical training, followed by at least three years' experience in responsible electrical engineering post, or such other experience as may be considered equivalent.

Salary, based on a 44-hour week : Basic Grade, £870 per annum at age 25, rising to £1350 (National rate) ; Main Grade, £1455 per annum, rising to £1990 (National rate). Entry into scales determined by qualifications and experience. Five-day week. Up to 25 working days paid annual leave. Paid sick leave entitlement. Paid public holidays.

Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D 317/0A. E9870

PUBLIC APPOINTMENTS

H.M. PRISON

WORMWOOD SCRUBS BORSTAL RECEPTION CENTRE

CIVILIAN INSTRUCTIONAL OFFICER, GRADE III, ENGINEERING

CIVILIAN INSTRUCTIONAL OFFICER, GRADE III, ENGINEERING for Vocational Guidance Dept., H.M. Prison, Wormwood Scrubs Borstal Reception Centre. Applicants must be aged at least 30 on 17th June, 1960.

Qualifications : Full apprenticeship plus at least 5 years' practical experience in Engineering and Metal work trades. City and Guilds Certificate (or equivalent) qualification in engineering. Capable of assessing aptitude and suitability by workshop and other tests of Borstal boys, aged 16 to 21, for trade training in Engineering and Metalwork trades.

Duties will include compilation of reports on Vocational recommendations and individual aptitudes.

London salary scale £915 to £1060. Prospects of pensionable employment. 44-hour week and holidays with pay. Quarters not provided.

Write Prison Commission, R.305/266, Horseferry House, Dean Ryle Street, London, S.W.1, for application form.

Closing date : 3 June, 1960. E9851

RHODESIA RAILWAYS

VACANCIES FOR SIGNALS AND COMMUNICATIONS ENGINEERS

Vacancies exist on the Permanent Staff for SIGNALS AND COMMUNICATIONS ENGINEERS for service in the Chief Engineer's Department of the Rhodesia Railways.

Preference will be given to applicants who have had previous experience in the design, installation and maintenance of modern colour light signalling and/or telecommunication systems with a Railway Administration or with a firm of equipment manufacturers.

Applicants should hold a degree in Electrical Engineering at a recognised University or be Corporate Members of the Institution of Electrical Engineers. Applicants who have passed Parts I and II of the Institution examinations will be considered for appointment to the grade of Technical Assistant until such time as they become Corporate Members and are, therefore, eligible for transfer to the Professional Grade. Successful candidates will be expected to become Corporate Members of the Institution of Railway Signal Engineers in due course.

The salary scale for Assistant Engineers is £1000 to £1800 per annum, plus a Cost of Living Allowance at present calculated on 12 per cent of the basic salary, subject to a maximum of £13 15s. per month. The commencing salary will depend upon previous experience of applicants. The annual increments in the above scale are as follows :

£1000 by £100 to £1200.
£1200 by £50 to £1500.
£1500 by £100 to £1800.

Further advancement to the grade of District Signals and Communications Engineer on the salary scale £1800 by £100 to £2100 is possible, as and when vacancies occur. Promotion to these posts is by selection.

Membership of the Contributory Pension Fund and Medical Fund is obligatory and the usual Railway privileges in respect of travelling concessions, leave, &c., will apply.

Income Tax in the Federation is not unreasonable, and at the present time, a married man with one child earning £1100 per annum, would not be liable.

Housing is provided at a moderate rental for married Engineers ; the rental payable is £7 10s. per month for Officers in receipt of a salary under £1700 per annum, and £10 per month for Officers in receipt of higher salaries.

Full particulars with regard to age, training, qualifications and experience should be submitted together with copies of recent testimonials to :

The London Agent,
Rhodesia Railways,
241, Salisbury House,
London Wall,
London, E.C.2,

from whom full details regarding conditions of service may be obtained. E9765

BOOKS and PUBLICATIONS

PITMAN FROM ALL BOOKSELLERS

PRESTRESSED CONCRETE

Theory and Practice

By P. B. Morice, B.Sc., etc., and E. H. Cooley, M.A.(Cantab.), etc.

This book gives a comprehensive treatment of both the theory and design of prestressed concrete structures and the practical problems involved in its use. Price 57/6 net.

THE HEAT TREATMENT OF STEEL

By Edwin Gregory, Ph.D., etc., and Eric N. Simons.

New and up-to-date Second Edition. Covers every phase of the subject from principles to practice. It is very easy to read, and explains what has to be done to different steels, and why it is necessary. Recent developments are dealt with. Price 35/- net.

PRINCIPLES OF SERVOMECHANISMS

By A. Tyers, A.M.Brit.I.R.E., and R. B. Miles, Grad.Brit.I.R.E.

The authors have written this book as a working aid for development and maintenance engineers. The book covers the functioning, performance, incorporation and setting up of these components. The electrical circuits are discussed in detail, and the great quality of the work is that no mathematical knowledge beyond that of elementary trigonometry is required. Price 25/- net.

Parker St., Kingsway, London, W.C.2

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HMSO

A Study of Alternative Methods of House Construction

In the search for improved building methods and lower costs, there have been differences of view about the relative merits of traditional and prefabricated building. This investigation attempts to resolve some of these differences and elucidate the conditions that new building methods must satisfy to reduce building costs. **7s. 6d.** (*post 6d.*)

Structural Loading in Factories

by H. V. Apcar, B.Sc., A.M.I.C.E.

Recommended to all concerned with factory design and construction. (Factory Building Study No. 4) **1s. 9d.** (*post 4d.*)

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HMSO

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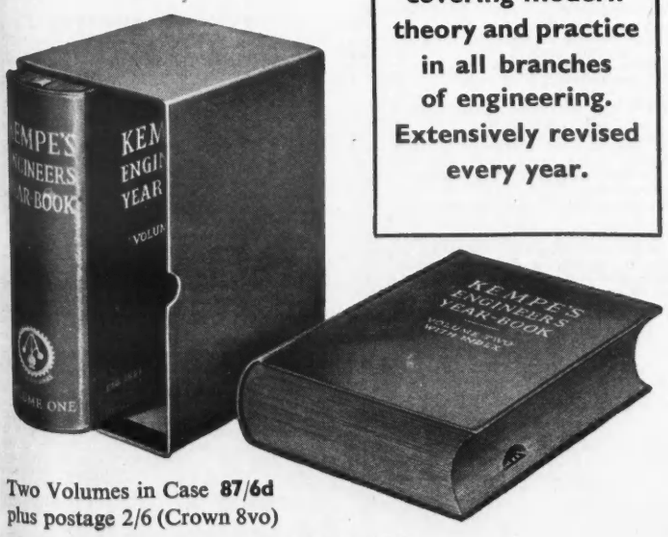

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PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

MIDLANDS PROJECT GROUP

ASSISTANT ENGINEERS

Applications are invited for the following appointments in the Midlands Project Group at Rugeley Power Station Site.

(a) SECOND ASSISTANT ENGINEER (MECHANICAL), N.J.B. Grade 4, £1195–£1545 per annum, Schedule "C."
Vacancy No. MPG.30/60.
Applicants should have had experience in the manufacture and erection of boilers, turbo-alternators and other mechanical equipment associated with a modern power station.
Appropriate technical qualifications will be an advantage.

(b) SECOND ASSISTANT ENGINEER (ELECTRICAL), N.J.B. Grade 4, £1195–£1545 per annum, Schedule "C."
Vacancy No. MPG.31/60.
Applicants should have had experience in the manufacture, erection, maintenance and operation of electrical plant, as installed in modern power stations.
Appropriate technical qualifications will be an advantage.

(c) THIRD ASSISTANT ENGINEER (MECHANICAL), N.J.B. Grade 5, £1090–£1300 per annum, Schedule "C."
Vacancy No. MPG.32/60.
Applicants should have a fundamental training in Mechanical Engineering and should have had experience in the manufacture and erection of mechanical equipment associated with a modern power station. Appropriate technical qualifications will be an advantage.

(d) THIRD ASSISTANT ENGINEER (ELECTRICAL), N.J.B. Grade 5, £1090–£1300 per annum, Schedule "C."
Vacancy No. MPG.33/60.
Applicants should have a fundamental training in Electrical Engineering and should have had experience in the manufacture, erection, maintenance and operation of electrical plant as installed in modern power stations. Appropriate technical qualifications will be an advantage.

(e) SECOND ASSISTANT ENGINEER (PROGRESS), N.J.B. Grade 4, £1195–£1545 per annum, Schedule "C."
Vacancy No. MPG.34/60.
Applicants should preferably possess a Higher National Certificate in either Mechanical or Electrical Engineering and have served a recognised engineering apprenticeship. Experience in the construction of heavy plant as installed in modern power stations, either in a manufacturers works or on site, is essential and a knowledge of the civil engineering work involved would be an advantage.

The selected candidate will be required to maintain up-to-date charts on the progress of the works on site in accordance with previously agreed programmes, and to assist the Resident Engineer in anticipating any divergence from these programmes. Ability to co-ordinate with Regional P.I.T. Officers will be required.

Applications for the above-mentioned posts should be made on standard form AE.6, available from the Administrative Officer, Midlands Project Group, P.O. BOX 314, 341, Bournville Lane, Birmingham, to be returned to him not later than 27th May, 1960. E9830

CHESTERFIELD, BOLSOVER AND CLOWNE WATER BOARD

ENGINEERING ASSISTANT

Applications invited for the above appointment. Salary in accordance with Special Grade (£785–£1070) but University Graduates in Engineering will be paid on Grade A.P.T. IV (£1065–£1220). Commencing salary according to qualifications and experience.

Preference will be given to candidates who are Corporate Members of the Institution of Civil Engineers and who have had experience in the waterworks industry.

The Board will assist, if required, in the matter of housing accommodation, and a motor-car allowance will be available. A medical examination for superannuation purposes will be necessary.

Applications, together with the names of two persons to whom reference can be made, should be sent to the Board's Engineer and Manager at New Beetwell Street, Chesterfield, not later than 27th May next.

RICHARD CLEGG,
Clerk to the Board.

Town Hall,
Chesterfield. E9818

SHEFFIELD CORPORATION WATERWORKS

APPOINTMENT OF TECHNICAL ASSISTANT

Applications are invited for the above appointment (Special Classes Grade £785 to £1070) on the permanent staff of the Waterworks General Manager and Engineer (A. B. Baldwin, M.Eng.). Commencing salary according to qualifications, ability and experience.

Applicants must be University Graduates or have passed Parts I and II of the examination of the Institution of Civil Engineers and in each case to have had at least five years' experience (including the period spent on theoretical training).

The post is superannuable and the successful applicant will be required to pass a medical examination.

Applications, stating age, education and training, qualifications, present and past appointments (with dates and salaries), and quoting the names and addresses of two referees, should reach the undersigned not later than 28th May, 1960.

JOHN HEYS,
Town Clerk.

Town Hall,
Sheffield, 1. E9822

PUBLIC APPOINTMENTS

AIR MINISTRY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary: £805 at 25 to £1095 at 34 or over, thereafter rising to maximum £1260, with increase for London, and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. 5-day week with 4 weeks' 2 days' leave a year initially. Special allowance in addition to salary during overseas service. Qualifications and experience:

(i) (a) University degree or equivalent diploma in electrical and/or mechanical engineering with at least 2 years' apprenticeship;
or (b) Graduate or corporate member of I.E.E. with at least 3 years' apprenticeship;
or (c) Graduate or corporate member of I.Mech.E., appreciable electrical engineering experience with at least 3 years' apprenticeship;
and (ii) Have been employed for minimum of 2 years with well-established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects between ages of 25 and 45. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D,158/OA. E9850

NORTH EAST METROPOLITAN REGIONAL HOSPITAL BOARD

40, EASTBOURNE TERRACE, LONDON, W.2

APPOINTMENTS

ENGINEERS (ELECTRICAL)

Salary according to age and experience, from £950–£1650. Applicants must be Corporate or Graduate Members of the Institution of Electrical Engineers and have passed the Institution's examinations or hold exempting qualifications. The posts offer opportunities to cover the whole field of electrical engineering in Hospitals.

ENGINEERS (MECHANICAL/HEATING AND VENTILATING)

Salary according to age and experience, from £950–£1650. Applicants must be Corporate or Graduate Members of Institution of Mechanical Engineers, or of the Institution of Heating and Ventilating Engineers, having passed the Associate Membership examination or holding exempting qualifications, or Associates of National College of Heating and Ventilating Engineers. The posts offer opportunities to cover the whole field of heating, ventilating and mechanical engineering in Hospitals.

ENGINEERING DRAUGHTSMEN

Salary according to age and experience, from £910–£1300. Applicants should hold one of the Higher National Certificates or Sections A and B of the Institution examination of the Institution of Heating and Ventilating Engineers, or an equivalent qualification, and should have suitable practical and theoretical training, including site or workshop experience.

The posts are pensionable, with good prospects of promotion.

Applications, giving age, present salary, qualifications and experience (with dates), together with the names of two referees, should be sent to the Secretary, North East Metropolitan Regional Hospital Board, 40, Eastbourne Terrace, W.2, within 14 days. E9858

WEST WILTS WATER BOARD

ASSISTANT CIVIL ENGINEER

ASSISTANT MECHANICAL/ELECTRICAL ENGINEER

Appointment of:
(1) ASSISTANT CIVIL ENGINEER. Special Grade (£785–£1070).
(2) ASSISTANT MECHANICAL/ELECTRICAL ENGINEER. Special Grade (£785–£1070).

Applications are invited for the above appointments. For Post (1) applicants should be Graduates of the Institution of Civil Engineers. Experience in water engineering and/or reinforced concrete design will be an advantage. For Post (2) applicants should be Graduates of the Institution of Mechanical and/or Electrical Engineers. Experience with automatic electrical pumping plant and control systems will be an advantage.

The successful applicants will be able to obtain varied experience in the design and construction of extensive capital works about to be commenced by this new Water Board.

Both posts are superannuable and subject to Charter conditions.

The headquarters of the Board are at Warminster, a pleasant residential town, midway between Bath and Salisbury. Some assistance towards housing accommodation may be given. A five-day week is operated.

Applications, stating age, status and qualifications, and giving full details of experience and the names and addresses of two referees, to be received by the undersigned not later than Monday, the 30th May, 1960.

J. A. YOUNG,
Engineer and Manager.

Craven House,
Warminster,
Wiltshire. E9834

Classified Advts. continued on page 120

TENDERS

INDIA STORE DEPARTMENT

The Office of the Director General, India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, invites TENDERS for the following :—

(a) SPECIAL PURPOSE CAPSTAN LATHES for Head Turning of Cartridge Cases to drawings available.

(b) MULTI-SPINDLE DRILLING MACHINES,
viz. 12 Spindle Machine 2 (Nos.)
18 Spindle Machine 2 (Nos.)

(c) UNIVERSAL THREAD GRINDING MACHINE.
Max. length between centres = 20in.
Max. dia. of work = 10in.
Similar to Matrix No. 39.

(d) UNIVERSAL THREAD GRINDER. Max. length between centres 11in. Max. dia. of work 2in.
Similar to Matrix No. 16.

Specifications, &c., can be obtained from the Co-ordination Branch, India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings per Tender enquiry, and is not refundable. Tenders are to be returned to the above address by Monday, 20th June, 1960. Specimen copy of the above enquiries can be seen at Engineering Branch, India Store Department, under the following references :—

(a) 2030/58/SSB/ENG.3.
(b) 2056/59/SSB/ENG.3.
(c) 2058/59/SSB/ENG.3.
(d) 2063/59/SSB/ENG.3. E9840

INDIA STORE DEPARTMENT

The Office of the Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the following :—

TENDER ENQUIRY No. 2062/59/ENG.2.
For the SUPPLY of TWO (Numbers) ELECTRIC BOGIE HAULAGE GEAR, 120-ton capacity, for Forging Furnace.

Specification, &c., can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings per Tender. The Tenders are due to be returned to India Store Department, at the above address, so as to reach them by 2 p.m. on Monday, 20th June, 1960.

Specimen copy of the above specification can be seen at Engineering Branch, India Store Department, Acton, W.3, under the following reference 2062/59/ENG.2. E9839

COUNTY OF NORTHUMBERLAND

COUNTY SURVEYOR'S DEPARTMENT

The above Council invite TENDERS for the SUPPLY of the following items of NEW HIGHWAY PLANT :—

Item 1.—10 (No.) Industrial Type Tractors with Trailers and Shovel Attachments.
Item 2.—10 (No.) Sweeper Brushes for Tractor Mounting.
Item 3.—10 (No.) Verge Edging Tools—" Somerset " type.
Item 4.—1 (No.) 20-ton Low Loader.
Item 5.—13 (No.) Diesel Wagons, 4 and 5/6 ton.
Item 6.—2 (No.) Personnel Carriers—12-Seater.
Item 7.—3 (No.) Motor Vans, 5/10 cwt. and 25/30 cwt.
Item 8.—6 (No.) Small Diesel Dumpers.
Item 9.—21 (No.) " Atkinson " type Gritters, 5-ton for lorry-mounting and 2-ton Trailer types.
Item 10.—22 (No.) Snowploughs, single blade and " V " types.

Specifications may be obtained from the County Surveyor, Phoenix House, Queen Street, Newcastle upon Tyne, 1.

Tenders in a plain sealed envelope, addressed to the Clerk of the County Council, County Hall, Newcastle upon Tyne, 1, should be delivered not later than 9 a.m. on the 6th June, 1960.

E. P. HARVEY,
E9842 Clerk of the County Council.

EDUCATIONAL

U.K.A.E.A.

HARWELL REACTOR SCHOOL

Control and Instrumentation of Reactors Course

The fifth course on " The Control and Instrumentation of Reactors," will be held at Durley Hall, Bournemouth, Hampshire, from the 12th to 23rd September, 1960, inclusive.

The course is intended for those who have a direct interest in the control and instrumentation of nuclear reactors, and it is assumed that participants have some knowledge of the basic principles of these subjects.

The fee for the course will be fifty guineas, exclusive of accommodation.

Application forms and further details can be had from :

The Principal,
Reactor School,
Atomic Energy Research Establishment,
Harwell,
Didcot,
Berks.

E9837 E

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London W.8. E114 E

UNIVERSITY OF LIVERPOOL

DEPARTMENT OF BUILDING SCIENCE

DIPLOMA IN BUILDING SCIENCE

A full-time COURSE consisting of Lectures, Laboratory and Drawing-Office work, leading to the DIPLOMA IN BUILDING SCIENCE, will be offered by the University in Session 1960–61. The Course will extend over three terms, commencing in October, 1960. Applications for admission are invited from persons of Graduate status in Civil Engineering, Architecture or Building.

Further particulars may be obtained from the Registrar, The University, Liverpool, 3. E9828 E

U.K.A.E.A.

HARWELL REACTOR SCHOOL

Standard Course No. 21

The next Standard Course will be held from the 29th August to 16th December, 1960, inclusive. The fee for the course is £250 exclusive of accommodation.

This course is intended primarily for engineers and physicists whose main interest is in reactor design.

Senior Technical Executives' Course No. 11

The course will be held from the 26th September to 7th October, 1960, inclusive. The fee for the course is fifty guineas exclusive of accommodation.

The course is an appreciation course for senior executives, and gives the background to nuclear engineering.

Application forms and details for both courses can be obtained from :

The Principal,
Reactor School,
Atomic Energy Research Establishment,
Harwell,
Didcot,
Berks.

E9836 E

SITUATIONS VACANT

An ambitious young UNIVERSITY GRADUATE MECHANICAL ENGINEER wishing to settle down in a progressive position where he will never have a dull moment cannot afford to overlook a vacancy existing in an old-established General Engineering Company in the Manchester area.

The Company acts both as Consulting Engineers and makers of a very wide range of specialised machines. The engineering problems arising in connection with the design and development of new plant and the production, installation and starting-up of machines on order are such as to tax the keenest brains. The immense variety of problems makes it essential for applicants to hold a University Degree in Mechanical Engineering, to be prepared to shoulder responsibility and to possess initiative and drive.

The Company has an extensive export trade with plenty of opportunities for world-wide travel.

Applicants need have no fear that the salary and other conditions of employment will not match up to their capabilities.

Initial interviews could be arranged in London if more convenient.

Apply, BOX No. E2868, " The Engineer." A

A PROGRESSIVE ENGINEERING COMPANY in the Victoria area of London requires a DRAUGHTSMAN for a responsible post in small Drawing Office. This post offers good prospects and an attractive salary to a man with general engineering experience. Five-day week and pension scheme in operation.—Please send details of experience to the Chief Draughtsman—THE WELLMAN BIBBY COMPANY, LTD., PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1. E9846 A

AREA WORKS ENGINEER required. Technical training at least to H.N.C. standard. Chemical works experience essential. Applicants should be over 26 years of age. Salary according to experience. Pension scheme.—Apply, stating experience and qualifications, to Personnel Manager, Howards of Ilford Limited, Ilford, Essex. E9855 A

ASSISTANT WORK STUDY OFFICER BIRMINGHAM

Candidates, who should possess a sound engineering background, must be experienced in work measurement and method investigation and fully conversant with latest techniques. A thorough knowledge of process charting is required. The location will be within the Birmingham area.

The salary for the appointment, which is pensionable and subject to medical examination, will be not less than £1150 per annum.

Applications, stating age, qualifications, and full details of experience, together with the names of two referees, should be addressed to the Industrial Relations Officer, West Midlands Gas Board, 6, Augustus Road, Edgbaston, Birmingham, 15. E9874 A

SITUATIONS VACANT

AN OLD ESTABLISHED COMPANY, manufacturing instruments in the scientific, light industrial and meteorological fields, wishes to expand in these or allied fields. Interested in manufacturing under licence or undertaking development work on suitable projects. Assembly facilities also available. —BOX No. E2835, " The Engineer." A

B. O. MORRIS LIMITED,
ALBION WORKS,
465, COMMERCIAL ROAD,
PORTSMOUTH
require
TWO SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN preferably with Machine Tool Experience and Technical Qualifications at least to O.N.C. The work comprises Structural, Mechanical and Jig and Fixture Design mainly for the Atomic Energy Authority. Please write full details.

E9663 A

DESIGN DRAUGHTSMEN for Project Development, required by HOOVER LIMITED. There are 2 positions. Applicants with a minimum qualification of H.N.C., either in Electrical or Mechanical Engineering, should be experienced in the design of light electro-mechanical devices and, in addition, a design knowledge of plastic mouldings, die-castings and press work is necessary. Age range 26–32. These posts carry attractive salaries, plus bonus.—Apply in writing, Employment Officer, Hoover Limited, Perivale, Greenford, Middlesex. E9872 A

DESIGNERS FOR SOUTH AFRICA

Large leading firm of heavy engineers and founders, undertaking the manufacture of heavy machinery and plant for mining, petroleum, chemical and allied industries, requires DESIGNERS with minimum qualification Higher National Certificate and several years' experience in design work. Candidates with lesser qualifications but with more extensive experience in one of the above-mentioned fields, will also be considered. Interesting, varied work in mechanical design calculations and on drawing-board requires sound ability in both.

Salary in accordance with ability, experience and qualifications. Liberal leave with additional long service benefits after six years. Medical benefit and Pension funds, Housing and assisted passage facilities available.

Apply in writing, giving full details of age, experience, qualifications and marital status, and enclosing a recent photograph, to :
The London Representative,
Vanderbijl Engineering Corporation, Ltd.,
723/737, The Adelphi,
John Adam Street,
LONDON, W.C.2. E9860 A

DRAUGHTSMAN, age 25-30, required for varied chemical plant development work. H.N.C. (Mechanical) and knowledge of plant layout and pipework essential. Permanent and progressive post. Superannuation and profit-sharing schemes.—Applications to : Personnel Manager, F. W. Berk & Co., Ltd., Canning Road, London, E.15. E9796 A

DRAUGHTSMAN

Versatile Engineering Draughtsman with general experience is required by a small but rapidly expanding Engineering Company situated in East London.

The work involved includes the design of machinery, light structures, &c. O.N.C. or H.N.C. desirable.

Applications stating age, qualifications and experience.—BOX No. E2836, " The Engineer."

A

DRAUGHTSMEN (senior) required by refractory engineers, previous experience desirable, on the design and detailing of incinerators, furnaces and structural steelwork. Salaries paid according to age and experience.—Write to Chief Engineer, Plibrico Co., Ltd., Westmorland Road, N.W.9. E9793 A

ENGINEER for Inspection of Cranes and Lifting Plant required by leading Insurance Company. Must have drawing-office experience of design of Cranes, also National Certificate in Mechanical Engineering. Areas, South Essex and Liverpool. Starting salary £800—other benefits—not over 38 years—permanent.—Write BOX E417, L.P.E., Romano House, 399-401, Strand, London, W.C.2. E9832 A

ENGINEER.—Well-known meat distributors with Head Office in London have vacancy for young Engineer as Assistant in their Engineering Dept. Applicants, preferably not over 30, must have had drawing office experience and be familiar with refrigerating requirements in small cold storage depots. Good salary and pension scheme. Write, giving age and details of experience and qualifications.—BOX No. E9740, " The Engineer." A

ENGINEERS FOR TECHNICAL ENGINEERING DEPARTMENT.—Duties include the preparation of mechanical/thermal schemes for power plant and allied projects. A good knowledge of basic thermodynamics, hydraulics and kindred subjects is essential. Experience in one or more of the following would be an advantage—(a) boiler design, (b) heat exchanger design, (c) gas turbine applications. The successful candidate will be centred in London, but will be expected to undertake short visits to site as required.—Applications, giving details of training, qualifications and experience, should be sent to Personnel Department, Ewbank and Partners, 10-11, Grosvenor Place, London, S.W.1. E9697 A

EXCELLENT SALARIES will be paid to fast and accurate TRANSLATORS who can meet the demanding requirements of a Midlands organisation handling engineering texts in many languages. Sound technical knowledge is essential. Send full details of training, career and present salary.—BOX No. E9866, " The Engineer." A

SITUATIONS VACANT

EXPERIENCED DESIGN ENGINEERS required for interesting work in a wide field of heat transfer application, with particular emphasis on large and small water-tube boilers. The work is interesting and varied. Applicants must have the ability and initiative to design complete units and ancillary equipment. There are several positions to be filled, mostly of a Senior nature. Salary according to experience and ability. Contributory Pension Fund. Staff Dining-room. State (in writing) age and experience.

Staff Manager, Foster Wheeler Limited, 3, Ixworth Place, London, S.W.3. E9867 A

EXPERIENCED SALES ENGINEER required for East Anglia, by pump manufacturers, to cover industrial, marine and agricultural fields ; car and expenses provided ; contributory pension scheme ; own staff advised of vacancy.—Applications, with full details, stating salary required, to Pump Department Manager, Gilbert Gilkes and Gordon, Ltd., Kendal, Westmorland. E9848

FITTERS AND MATES, must be A.E.U. Able to travel. Good outside allowances. Please apply.—BOX No. E2871, " The Engineer."

FOSTER WHEELER LTD.

DESIGN ENGINEERS

Engineers required for interesting work on varied Heat Transfer Equipment in expanding Design Department. Wide variety of products, including Heat Exchangers, Condensers, Vacuum Equipment, Cooling Towers, High Pressure Loops for Nuclear Energy Application. Degree or Institute qualifications preferred, but Higher National considered with specialised knowledge. Experience in Steam and Heat Transfer and good practical training essential. Salary dependent on qualifications and experience.

DRAUGHTSMEN

Draughtsmen required for work in Design Department on wide variety of Steam Equipment, High Pressure Loops and Nuclear Applications. Good opportunity to work on new projects and to develop original designs. Higher National preferred, but experience in Steam Engineering or Heat Exchangers essential. Salary dependent on qualifications and experience.

Write, please, to the Staff Manager (C/T), Foster Wheeler House, 3, Ixworth Place, London, S.W.3. E9853 A

FURNACE ENGINEERS/ DRAUGHTSMEN

Four Senior Design/Section Leaders and eight Draughtsmen required for all types of furnaces and associated mechanical equipment as used in steelworks and non-ferrous industries.

Experience in steelworks and non-ferrous industries desirable but not essential. Salary will be dependent on qualifications and experience.

Non-contributory pension scheme.
Disturbance allowance considered.

Applications to the Director of Administration, Salem Engineering Co. Ltd., Milford House, Milford, Nr. Derby. E9807 A

HYDRO-ELECTRIC ENGINEERS. Civil Engineers, age 25 to 30, required to take charge of sections of construction sites in Inverness-shire. Salaries according to qualifications and experience.—Apply in writing, giving full details, to Sir William Halcrow and Partners, Alliance House, Caxton Street, London, S.W.1. E9868 A

J. DOUGLAS MATHEWS AND PARTNERS, Chartered Architects, require experienced RESIDENT SITE SUPERVISORS on a permanent staff basis. Applicants must be prepared to go anywhere in the United Kingdom for resident appointments of one, two or three years. Salary £1250–£1750, according to job, experience and qualifications.—Applicants to give names of at least three architect or engineer references.—Reply to 3, Ebury Street, London, S.W.1. E2840 A

PLATT BROS. & CO., LTD., Oldham, require a DRAUGHTSMAN for their plant and maintenance Department with some experience of plant layout and works services. Qualifications : H.N.C. or O.N.C., with suitable experience, would be acceptable. Age 25 or over. Salary commensurate with qualifications and experience.—Apply by letter or in person to the Personnel Manager, Arkwright Street, Oldham. E9869 A

SITUATIONS VACANT

LANCASHIRE TAR DISTILLERS require a DRAUGHTSMAN for their Engineering Dept. Applicants should be at least 23 years of age, with experience in chemical plant, pipework, &c., and should preferably be of H.N.C. standard.

The work is varied and interesting and would include some site work. Superannuation scheme, staff canteen.

Applications, in confidence, stating age, qualifications and experience, to :

Chief Engineer,
Lancashire Tar Distillers Ltd.,
Engineering Dept.,
Liverpool Road,
Cadishead,
Nr. Manchester. E9861 A

POWER STATION CHEMIST
ELECTRICITY DEPT.,
CAPE TOWN, SOUTH AFRICA

A vacancy exists in the Generation Branch of the Electricity Department of the city Council of Cape Town, South Africa, for a suitable qualified person for the position of Power Station Chemist.

The scale of pay (total emoluments) applicable to the post is £1560, with two increments of £60 to a maximum of £1680 per annum.

Applicants must possess a Degree in Chemistry of a recognised University or an equivalent qualification. They must have had experience in a power station laboratory and be familiar with the methods of sampling and analysis of materials used in a Power Station, preferably with advanced steam conditions. A knowledge of nuclear physics and the use of radio-active isotopes will be an advantage.

Persons possessing the requisite qualifications and experience are invited to apply not later than MONDAY, 23RD MAY, 1960, and to address their applications to :—

Messrs. Merz and McLellan,
Carliol House,
Newcastle upon Tyne,
ENGLAND,

from whom further particulars relating to the vacant position may be obtained.

E9650 A

PRODUCTION PROGRESS MANAGER required by Light Electrical Engineering Company in S.E. London. Candidates must be experienced in planning of factory loading, control of production and purchasing progress teams. Applications treated in strict confidence ; give full particulars, age and salary required.—BOX No. E2869, " The Engineer." A

PROGRESSIVE ENGINEERING FIRM requires capable ENGINEER for Design complex modern welded plate and tubular structures. Some mechanical experience an advantage. Salary according to qualifications and experience. Permanent pensionable appointment.—BOX No. E9838, " The Engineer." A

SENIOR DESIGNER required by Drysdale and Co., Ltd., Yoker, Glasgow, W.4. An excellent opportunity is open to a suitable man over 25 years of age. Applicant should preferably have experience in the design and installation of Centrifugal Pumps and their associated machinery. Life Assurance and Pension Scheme in operation. Five-day week.—Apply to the Secretary, giving full details of qualifications and salary required. E9785 A

TECHNICAL REPRESENTATIVE required for London Office of Scottish Heavy Engineering firm. Marine Engineering background, and with experience of Boilers, Pressure Vessels, Evaporators, &c. Apply, giving details of age and experience.—BOX No. E2870, " The Engineer." A

THE GLACIER METAL COMPANY

Invites applications for the post of

SENIOR APPLICATIONS ENGINEER

The Company has recently established within its Research and Development Organisation a new department whose function is to use the latest research knowledge in advising customers on all aspects of bearing design.

An appointment has now to be made in which the Engineer will be responsible to the Manager of the new department and will have initially one assistant. The work entails a wide and interesting range of contacts in the engineering industry.

As Technology advances new mechanical designs raise new bearing problems and new bearing designs make possible innovations in the design of machinery. A senior Applications Engineer is responsible both for devising solutions to bearing problems raised with the Company by its customers and for searching out areas where such innovations are practical.

Applicants should have a good Honours Degree in Engineering, Physics or Mathematics, together with a completed apprenticeship. Experience in Research, Design or Development work would be useful.

Salary Range : £1350 to £1830 per annum.

Applications should be sent to

Personnel Divisional Manager (Ref.: SAE),
The Glacier Metal Company,
Ealing Road, Alperton, Wembley, Middx.

E9783 A

THE BRITISH BRUSH MANUFACTURERS RESEARCH ASSOCIATION, c/o Department of Textile Industries, The University, Leeds, 2, wishes to appoint a young ENGINEER with a University Degree or equivalent, to study machinery and equipment used in the manufacture of brushes of all types. E2866 A

SITUATIONS VACANT

THE MANCHESTER SHIP CANAL COMPANY

The Manchester Ship Canal Company invite applications for the appointment of ASSISTANT CIVIL ENGINEERS on the established staff of the Chief Engineer. Scale of salaries : £845 at age 25, rising by annual increments to £1310 at 38, with prospects of promotion to higher grades at salaries up to £1795.

Candidates should be Corporate Members of the Institution of Civil Engineers or hold equivalent qualifications, and should have experience in design, specifications, construction and maintenance of Civil Engineering works. Harbour and dock experience is preferable but not essential.

Successful applicants will require to become members of the Company's Contributory Superannuation Scheme.

Applications, stating age, qualifications and experience, should be addressed to the Chief Engineer, The Manchester Ship Canal Company, Ship Canal House, King Street, Manchester, 2, not later than 18th June, 1960. E9845 A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, " The Engineer." A

WANTED IN LANCASHIRE

ENGINEER-REPRESENTATIVE with good general engineering knowledge—especially electrical plant and pumps.—Write, stating qualifications and experience to

THOMAS MITCHELL AND SONS LIMITED,
BOLTON

E9787 A

DEVELOPMENT ENGINEER

A Graduate Engineer is required for the appraisal of new techniques and study of materials, equipment and design leading to the preparation of Standards &c., for equipment in the low-temperature field.

Write:—

PERSONNEL MANAGER,
AIR PRODUCTS (G.B.) LTD.,
49/50, Poland Street,
London, W.1.

E9816 A

THE GENERAL ELECTRIC COMPANY, LIMITED
ATOMIC ENERGY DIVISION

Opportunities exist for young mechanical engineers to work in a development laboratory handling the mechanical engineering problems that arise in the design and construction of nuclear power stations.

DEVELOPMENT ENGINEERS

qualifications required are a mechanical engineering apprenticeship and a degree or equivalent. Some drawing office experience would be an advantage.

ASSISTANT DEVELOPMENT ENGINEERS

Qualifications required are a mechanical engineering apprenticeship and H.N.C., or be studying for H.N.C. Drawing office experience would be an advantage, but successful candidates without this can spend an initial period on the board.

Applications should be made to Personnel Manager (DWB/20), The General Electric Company Limited, Erith, Kent.

E9835 A

SITUATIONS VACANT

PRODUCTION-ENGINEERING LTD. have been asked to advise the Directors of a well-known National group of companies on the appointment of a

WORKS MANAGER

with a view to early

DIRECTORSHIP

for a subsidiary in the West country.

The appointment requires courage and resourcefulness in the management of a small engineering business. Success is likely to lead to much wider responsibilities.

Applicants should be 33-45, hold a University degree or equivalent in mechanical engineering, and have a record of practical management experience. Salary for this interesting appointment will be between £2,000 and £2,500 per annum.

Applications, which will be treated in strict confidence, should be addressed to Production-Engineering Ltd., 30 Waterloo Street, Birmingham, 2.

E9859 A

BRITISH TRANSPORT COMMISSION

British Transport Commission invite applications for the following posts in the Chief Signal Engineer's Department, at 222, Marylebone Road, N.W.1 :

(Post A) Assistant (Development) : Salary Range £1,815–£2,155.

Wide experience in design, manufacture and application of electrical apparatus in the field of railway signalling. Conversant with modern materials and techniques for this purpose, including the application of electronics, and competent to direct the activities of design teams. Professional qualifications essential.

(Post B) Assistant (Equipment) : Salary Range £1,420–£1,695.

Wide experience in design and development in electric and electro-mechanical signalling apparatus. Ability to employ modern materials and techniques for this purpose.

(Post C) Assistant (Electronics) : Salary Range £1,200–£1,420.

Experience in original circuit design for electrical signalling systems. In particular, required to be familiar with the use of electronic techniques for this purpose.

Superannuation scheme : certain travel facilities : medical examination. Write, stating post reference, age, qualifications and experience, to Director of Establishment, British Transport Commission, 222, Marylebone Road, London, N.W.1, within 14 days.

E9863 A

Central Electricity Generating Board

TRANSMISSION DEPARTMENT

Headquarters, London, S.E.1.

CIVIL ENGINEER (TRANSMISSION)

required in the **Civil Engineering Sub-Branch of the Transmission Construction Branch.**

Candidates must be Corporate Members of one of the recognised Engineering Institutions by examination and/or hold a University Degree in Civil Engineering and have a wide experience of general Civil Engineering work.

The successful applicant will be in charge of the Civil Engineering Sub-Branch which is responsible for all aspects of the design and construction by contract of the civil engineering and building work required in connection with the establishment or extension of high voltage sub-stations.

Salary within the range £2,820—£3,020 p.a.

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24-30, Holborn, London, E.C.1, by 7th June. Envelopes should be marked " Confidential Ref. ENG/186."

E9844 A

Classified Advts. continued on page 122

SITUATIONS VACANT

BRISTOL SIDDELEY ENGINES

An interesting and responsible vacancy exists at BRISTOL SIDDELEY ENGINES LIMITED, COVENTRY DIVISION, for a

WELDING ENGINEER

Applicants must be fully experienced in all types of welding to Lloyd's standard and also all classes of welding techniques, including Resistance, Electric Arc, Argon Arc and Gas to AID standards.

A full knowledge of welding theory is essential and an ability to work in close liaison with the Design Staff will be necessary.

The appointment will carry Senior Staff status together with a salary commensurate with the ability, experience, qualifications and age of the successful candidate.

Please apply, in strict confidence, giving full details, to: The Personnel Manager, Bristol Siddeley Engines Limited, Coventry Division, PO Box 17, Coventry.

E9820 A

SITUATIONS VACANT

BRITISH TRANSPORT COMMISSION invite applications for the following post at the British Railways School of Transport, Derby :—

DIESEL TRACTION INSTRUCTOR
(MECHANICAL ENGINEERING)
Salary Range £838 — £1,130

Instruct Technical and Supervisory staff in the principles, construction, operation and maintenance of Diesel Locomotives and Multi-Unit Stock. Sound theoretical knowledge and practical experience of Medium and High Speed Diesel Engines used in Rail Traction essential. Knowledge of electrical transmission and control systems desirable. Professional Mechanical Engineering qualifications required. Experience in teaching desirable. Post is non-residential.

Superannuation scheme ; certain travel facilities ; medical examination.—Write, stating age, qualifications and experience, to Director of Establishment, British Transport Commission, 222, Marylebone Road, London, N.W.1, within 14 days. E9861 A

SITUATIONS VACANT

HARVEY

require

SENIOR DRAUGHTSMEN AND ESTIMATORS

with experience in pressure vessel and large welded fabrication work for the Oil and Chemical Industries to British and American Codes.

Assistance will be offered, if necessary, with regard to accommodation.

Apply, stating age, full details of experience and qualifications, and salary required, to :

Personnel Manager,
G. A. HARVEY & CO. (LONDON), LTD.,
WOOLWICH ROAD, LONDON, S.E.7.

E9865 A

I.C.I. (HYDE) LIMITED

MECHANICAL ENGINEER

I.C.I. (Hyde) Limited, manufacturers of polyvinyl coated fabrics, plastic sheet and film and related products, has a vacancy for a Mechanical Engineer. Age 25–35. Duties will include machine design, plant development work and plant layout. Applicants should have a good honours degree followed by practical training and some experience of design and development work. Experience in the design of machinery similar to that used in the rubber, plastics, or leathercloth industries desirable, but not essential.

Conditions of employment include an attractive salary, membership of the Staff Pension Fund and participation in the Company's Profit-Sharing Scheme. A married man will receive assistance with removal expenses and may also be paid a lodging allowance for a period of up to six months whilst maintaining two homes. In addition, he will be eligible for assistance with house purchase.

Write, giving brief details of age, qualifications and experience, to :

Staff Officer,
I.C.I. (HYDE) LIMITED, Newton Works, Hyde, Cheshire

E9829 A

BRITISH TRANSPORT COMMISSION

British Transport Commission require ASSISTANT PROJECTS DEVELOPMENT ENGINEER (DESIGN) for Locomotive Carriage & Wagon Development Unit, located at Darlington. Applicants should have a good general education to Higher National Certificate in Mechanical Engineering or equivalent, have served an apprenticeship in a Railway or contractor's works, preferably engaged on Railway rolling stock, and possess intimate knowledge of the design of such stock. Capable of taking charge of an office engaged on new developments in connection with locomotives, carriages and wagons.

Salary range : £1590–£1920. Superannuation Scheme. Certain travel facilities. Medical examination. Write, giving age, qualifications and experience, to Director of Establishment, British Transport Commission, 222 Marylebone Road, London, N.W.1, within 14 days.

E9847 A

SENIOR DRAUGHTSMEN

for old-established company specialising in bulk mechanical handling machinery and modern foundry mechanisation. Progressive well-paid and permanent jobs for right men. Five-day week, 3 weeks annual holiday, luncheon vouchers. (Holiday arrangements honoured.)

Apply :

Personnel Director,
MARCO CONVEYOR & ENGINEERING CO. LTD.,
Lynn Road, Leytonstone,
London, E.11.
LEY 2254.

E9734 A

ELECTRICAL ENGINEERING ASSISTANTS

We are continuing to expand our building development throughout the British Isles. Our projects are varied and on a large scale, giving ample scope for initiative and responsibility.

Applications are invited from Electrical Engineering Assistants, preferably of A.M.I.E.E. or H.N.C. level, who should be experienced in the design of systems in large stores and commercial buildings.

Generous salaries and expenses will be paid. Good Staff Life Assurance and Pension Scheme is in operation, together with a five-day week.

Applications in writing to:—

Employment Manager,
(Ref: EEA/45/TE),
Littlewoods Mail Order Stores, Ltd.,
Spinney House,
Church Street, Liverpool, 10.

E9843 A

Monsanto Regd.

MONSANTO CHEMICALS LIMITED

ASSISTANT ELECTRICAL ENGINEER

Men, aged 30 years or over, with design and practical experience of electrical installation as found in the heavy chemical and petroleum industries, are invited to apply for a post of Assistant Electrical Engineer in the Engineering Department in London. Minimum qualifications H.N.C. and Corporate Membership of the Institution of Electrical Engineers.

Excellent salary and career prospects ; non-contributory pension scheme and other benefits.

Please send written applications, giving details of age, qualifications and experience, to DL 140, Personnel Department, Monsanto Chemicals Limited, Monsanto House, 10-18, Victoria Street, London, S.W.1.

E9849 A

SITUATIONS VACANT

PLANNER/SCHEDULER

to prepare Project Schedules and Programmes for orders and work load forecasts for the Workshops and Engineering Department.

Applicants must have experience as Planners for a Process Equipment Fabricator and be in possession of H.N.C. (Mech.) or equivalent in experience.

Write:—

PERSONNEL MANAGER,
AIR PRODUCTS (G.B.) LTD.,
49/50, Poland Street,
London, W.1.

E9817 A

BENNETT, SONS & SHEARS, LTD.

require

CHIEF CHEMICAL ENGINEER

A vacancy will shortly occur at our Leeds Works for an experienced and qualified Chemical Engineer, to take charge of the Company's Food and Chemical Section, this forming part of the Engineering Division.

All applicants should preferably have design experience in Distillation, Evaporation and Vacuum work.

The position will involve contact with customers, in addition to technical responsibility for the section.

There are excellent opportunities for advancement in a small progressive firm, and a contributory pension scheme is in force. Salary will be according to experience with a minimum of £1700 per annum. A Company car will be provided and housing facilities will be offered if required.

Applications will be treated in strict confidence and should be addressed to :

The Chief Engineer,
Bennett, Sons & Shears, Ltd.,
Pepper Road, Leeds, 10. E9824 A

SITUATIONS VACANT

LAING

The following vacancies exist in the Research and Development Centre at Boreham Wood. The work is of an interesting nature and concerned with the development of new machines and processes connected with the Building and Civil Engineering industries.

MECHANICAL ENGINEERS AND GRADUATES

or Engineers with H.N.C. or equivalent are required for work involving the study, performance and development of the Mechanisation techniques applied within the Contracting Industry. Site experience in the operation of Contractors' Plant an advantage.

DRAUGHTSMEN

Senior and Junior Draughtsmen are required for work on the development of new and improved types of Contractors' Plant.

All these posts are permanent and progressive. Pension Scheme. Applicants should write in the first instance to :

PERSONNEL MANAGER (M.D.E.6),
JOHN LAING AND SON, LIMITED,
LONDON, N.W.7

E9731 A

SITUATIONS VACANT

CENTRAL ELECTRICITY GENERATING BOARD

HEADQUARTERS DRAWING OFFICE

Due to internal promotions the Board has the following vacancies at Bankside House, Sumner Street, S.E.1:—

(A) One SENIOR CIVIL ENGINEERING DRAUGHTSMAN with design experience on reinforced concrete work.

Commencing salary within the range £830 to £940 p.a.

(B) CIVIL ENGINEERING DRAUGHTSMEN for detailing reinforced concrete, foundation and general civil engineering work. Opportunities to gain experience on design work and for upgrading as vacancies occur.

Salary £660 to £780 p.a.

(C) One SENIOR DRAUGHTSMAN Experienced on 132/275kV layout and schematic diagram work.

Salary £980 to £1080 p.a.

Also

Two EXPERIENCED FEMALE TRACERS at a salary according to experience and ability which rises to a maximum of £630 p.a.

This year's holiday arrangements honoured.
Permanent pensionable appointments.
Staff Restaurant. Sports and Social Club.

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24/30, Holborn, London, E.C.1. Envelopes should be marked "Confidential Ref. ENR/167."

E9747 A

TECHNICIAN

required at

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

to assist in developing ultrasonic non-destructive testing techniques for flaw detection monitoring of the rotors of large electrical machine, and to work on equipment for torsional twist measurements, and other metrology problems. Duties connected with the operation of a large power plant may be included later.

Applicants should have served a recognised engineering apprenticeship or have had equivalent training.

Experience in ultrasonic testing an advantage and O.N.C. in Electrical Engineering desirable.

Salary : £925 (linked to age 30)–£1105 p.a.

Housing and contributory pension scheme.

Send POST CARD for details to the Group Recruitment Officer (1647/25), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

E9827 A

Would you like to work in a peaceful atmosphere with beautiful country around you?

Group of Engineering Companies with modern offices in Hereford require:

(1) Technical and Commercial Sales Manager with experience of industrial air conditioning and refrigeration for home and export.

(2) Development Engineer.

(3) Sales Engineers.

(4) Refrigeration, Mechanical and Hydraulic Draughtsmen and Estimators.

5 day week. Contributory pension scheme. Applications, which will be treated in strict confidence, should be made in writing stating age, experience, salary required, &c., to Managing Director, Denco Works, Hereford. E189 A

TRINIDAD OILFIELD SERVICE LIMITED,

TRINIDAD, W.I.

The above Company, who operate Technical Services to the Oil Producing Industry, require for service in Trinidad:

ENGINEERS (preferably Mechanical) who are at least either Graduate Members of the Institutions of Mechanical or Electrical Engineers or who have educational qualifications exempting them from the Institutions' examinations. There is also a vacancy for a GRADUATE PETROLEUM ENGINEER.

Salary, depending on qualifications, plus pension fund, assisted housing and home leave every two years with passage allowances.

Please send full details to the Company at P.O. Box 69, San Fernando, Trinidad, West Indies, enclosing recent photograph. Interviews will be arranged in the U.K.

E2845 A

SITUATIONS WANTED

CHIEF DRAUGHTSMAN (STRUCTURAL). Live man requires post in the above capacity, with progressive company. 25 years' experience, all branches. Estimating to erection.—BOX No. E2833, "The Engineer." B

ENERGETIC 30 YEARS OLD Executive Director, with sales and production experience in light engineering industry, seeks Directorship with progressive small or medium-size company engaged in the production and sales of their own branded products. Capital available.—Write, BOX MY/66, c/o 95, Bishopsgate, E.C.2. E9823 B

EXPERIENCED ENGINEER, M.I.Mar.E., M.I.Plant.E., age 38, seeks progressive post as Works or Plant Engineer or similar, anywhere in U.K. Present salary £1500.—BOX No. E2864, "The Engineer." B

FOR HIRE

LATTICE STEEL ERECTION MASTS (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. E103 K

BUSINESS OPPORTUNITIES

ABSTRACTORS, TRANSLATORS AND EDITORS, FREELANCE, required for Russian, Czech, Polish, French and German in : physics, geophysics, metallurgy, electrical, electronic, mechanical and production engineering, aerodynamics and aviation, automation, power generation, fuel. Regular long term assignments.—BOX No. E2843, "The Engineer." O

CONSULTING ENGINEERS with technocommercial office in Milan with excellent connection with major petroleum, chemical and power industries in Italy are prepared to act as representatives of the following interests : Project engineering for industrial, chemical and thermal plants ; manufacturers of general processes equipment.—BOX No. E2865, "The Engineer." O

REMPLOY SPONSORSHIP SCHEME

Send for details which show an attractive proposition to manufacturers.

Write to the MANAGING DIRECTOR, REMPLOY LTD., 25-28, BUCKINGHAM GATE, S.W1, or telephone VICtoria 6621 (12 lines).

E9665 O

A BARGAIN. £25 complete. BRAND NEW READY-MADE CO. REGNS. Guaranteed no trading (ENGLAND OR SCOTLAND)—all trades available NOW, including Engineering ; Electrical Engineering ; Motor Engineering ; Garage ; Machinery ; Metal ; Haulage ; Hire Purchase ; Investment ; Property (specially prepared for each trade).—BUSINESS ECONOMY CO. REGNS. LTD., Dept. T/16, 156, Strand, London, W.C.2. (Tem. 8377/2294), for English companies, and to 19, Walker Street, Edinburgh, 3 (Cal. 1167/8/9), for Scottish Companies. Read "ADVANTAGES OF TRADING AS A LIMITED COMPANY" (3s. post free) ; Limited Co. may save you tax. We have seven-day Co. Regn. service with your own choice of name. £21 complete, plus stamp duties. E182 O

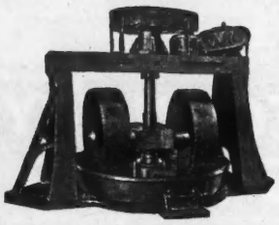
SUB-CONTRACTING

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

MOBILE LIFTING SERVICE. Lump Sum or Hire Rate quoted for any lifting work by Lorry-Mounted or Crawler Cranes, any size, any area.—TARSLAG, LTD., Rotherham 78481. E187 MW

Classified Advts. continued on page 124

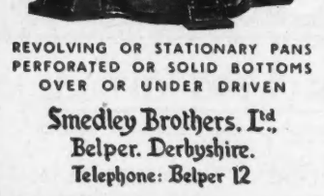
TRADE Smedley MARK
PAN GRINDING MILLS



REVOLVING OR STATIONARY PANS
PERFORATED OR SOLID BOTTOMS
OVER OR UNDER DRIVEN

Smedley Brothers. Ltd.
Belper. Derbyshire.
Telephone: Belper 12

Enter No. 1241 on reply card



YOU'LL
KEEP THINGS ROLLING
if you *remember*
WARDS might have it!
THOS. W. WARD LTD
ALBION WORKS, SHEFFIELD

BUSINESSES & PREMISES

COLCHESTER, ESSEX.—A new Factory will be erected to reasonable requirements. Up to 60,000 sq. ft. on main road corner site of about 3 acres where a number of new factories are existing. Owners will let or sell. Plans and particulars available.—Apply, Developers, 18, Upper Brook Street, W.1. E9821 L

ENGINEERING BUSINESS, Scotland. Strong asset position, good profits. Price £120,000.—Details from J. Mosely and Partners, Ltd., 9, Southampton Place, W.C.1. E2844 L

MISCELLANEOUS

ALL TYPES OF COMMERCIAL AND TECHNICAL GERMAN/ENGLISH, ENGLISH/GERMAN TRANSLATIONS undertaken. Work guaranteed to be done efficiently and promptly by native Austrian. Rates: Commercial, 72 words 1s. 6d.; Technical 3s. All work typewritten.—BOX No. E2872, "The Engineer." I

LUSOL
KILLS RUST AND LUBRICATES

LUSOL The Rust Solvent is invaluable for Dismantling, Repairing and Overhauling Engineering Equipment. Obtainable from your usual Supplier. Enquiries to the manufacturers:—

The Great Eastern Oil Co., Ltd.,
372, Scotland Street Glasgow. Tel.: South 2207
E184 I

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THE PROPRIETORS of British Patent No. 773,746 for "IMPROVEMENTS IN AND RELATING TO ROTARY JOINTS," desire to enter into negotiations with a firm or firms for the sale of the Patent or for the grant of licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E9831 H

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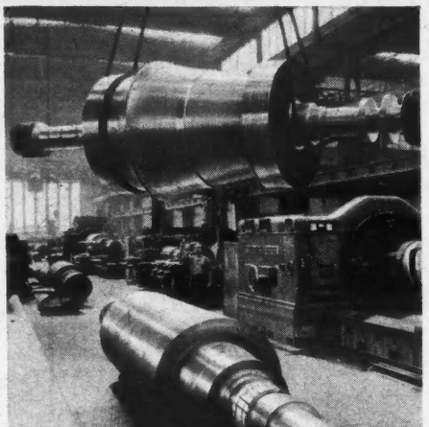

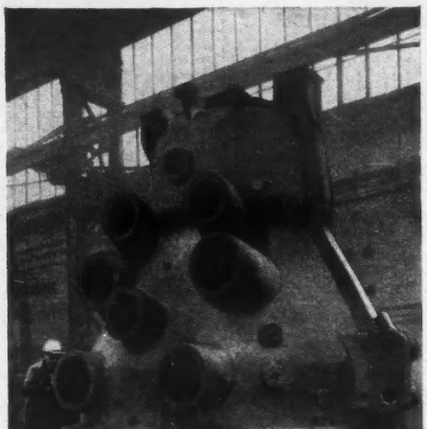

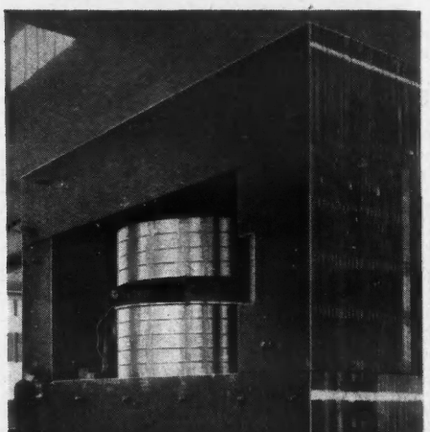

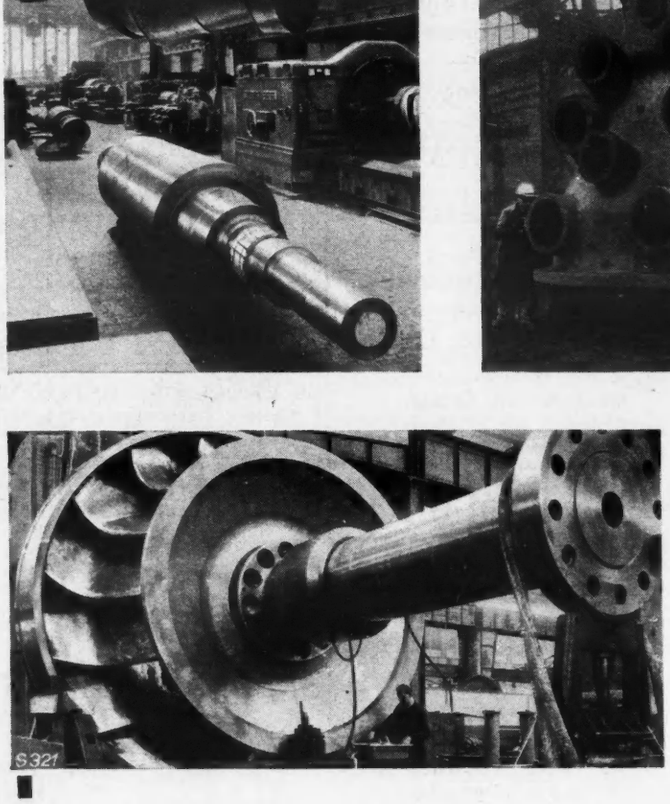

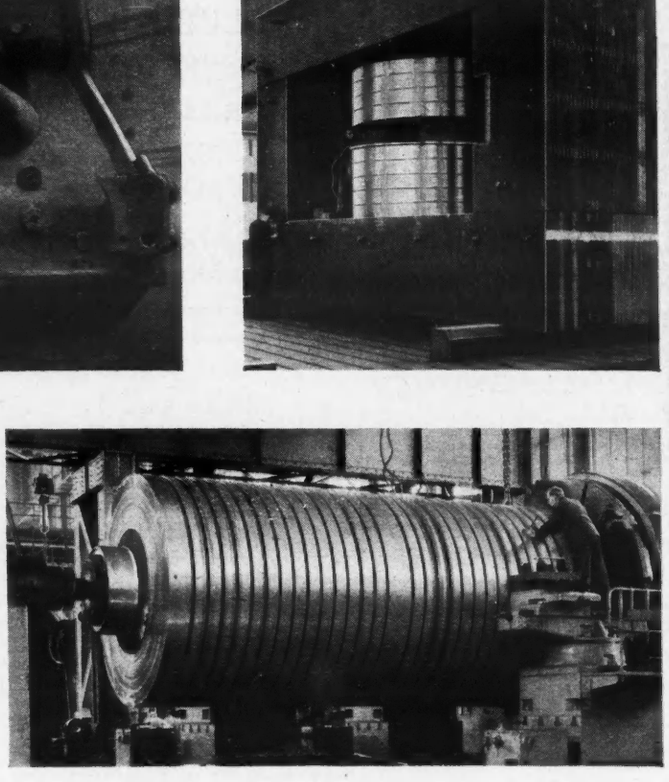

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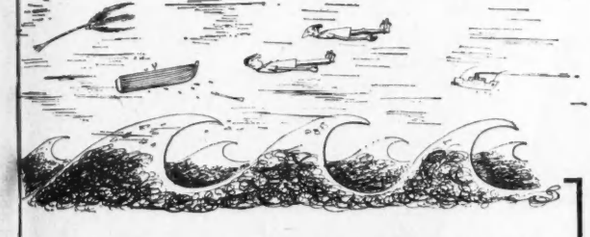

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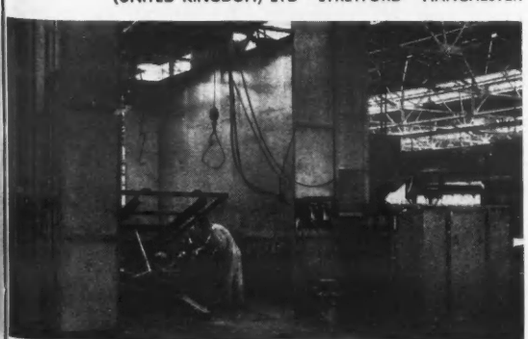

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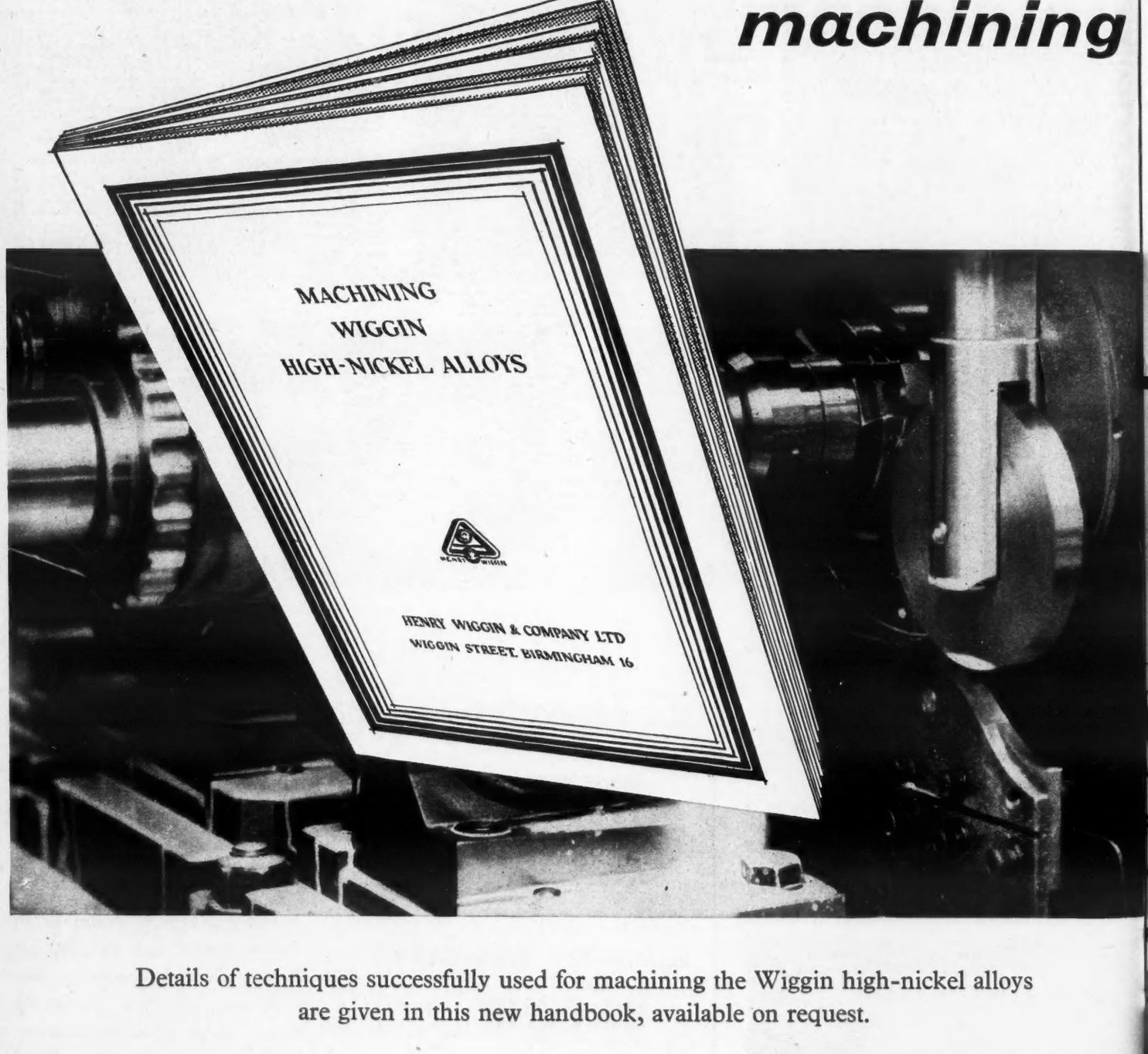

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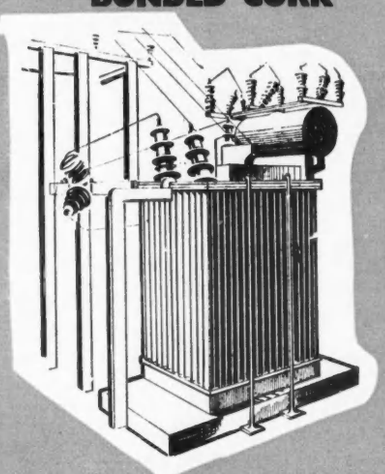

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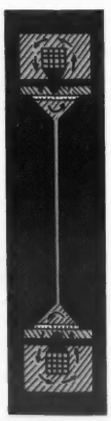

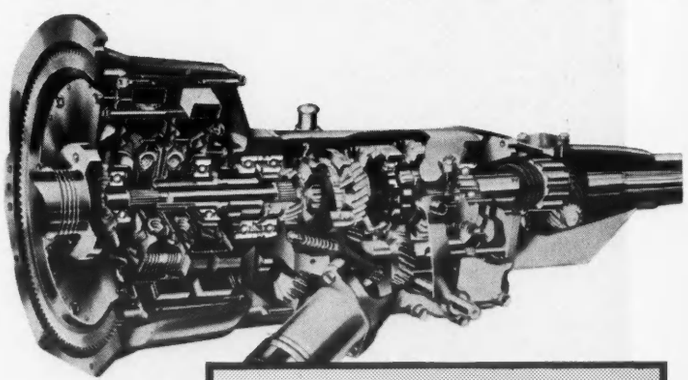

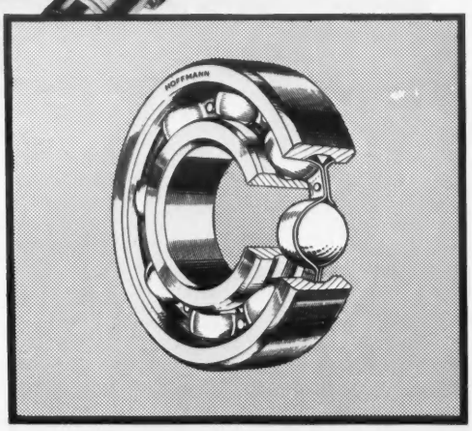

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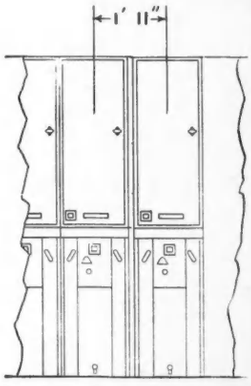
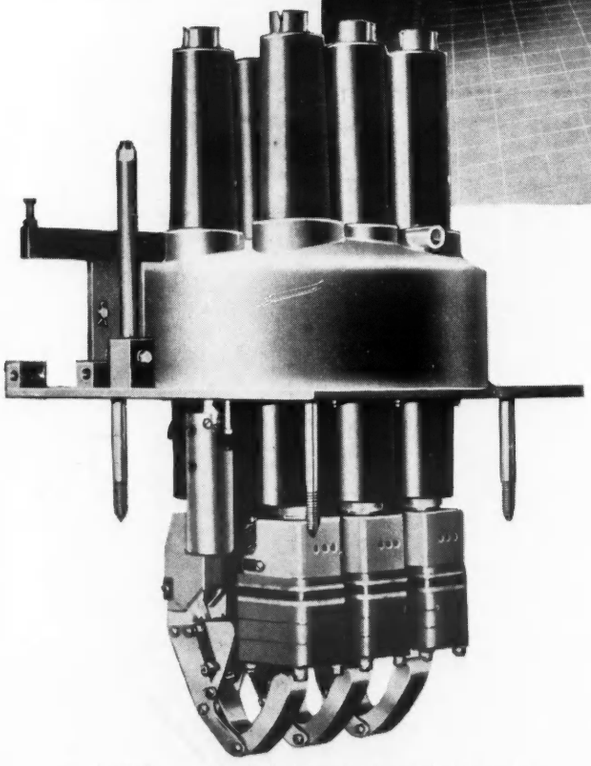


A 6-panel, Class QF441-461 Switchboard with spring-operated mechanism.



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